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Appendix
I
1842 – '67

DISCUSSION
OF
METEOROLOGICAL PHENOMENA
OBSERVED AT THE
# U. S. NAVAL OBSERVATORY.
FROM
JUNE 30, 1842, TO JANUARY 1, 1867.

A. Hall

APPENDIX I.

DISCUSSION
OF
METEOROLOGICAL PHENOMENA
OBSERVED AT THE
# U. S. NAVAL OBSERVATORY,
# WASHINGTON,
FROM
JUNE 30, 1842, TO JANUARY 1, 1867.

PREPARED BY ORDER OF
COMMODORE B. F. SANDS, U. S. NAVY,
SUPERINTENDENT,

BY J. R. EASTMAN,
Professor of Mathematics, U. S. Navy.

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1868.

APPENDIX I.

METEOROLOGICAL OBSERVATIONS

AT THE

UNITED STATES NAVAL OBSERVATORY,

FROM JUNE 30, 1842, TO JANUARY 1, 1867.

From the establishment of the "Depot of Charts and Instruments," in 1842, to January, 1867, a portion of the working force attached to this institution—now known as the United States Naval Observatory—has been employed in making and reducing meteorological observations obtained with the Barometer, the Dry and the Wet bulb Thermometers, the Sun Thermomometer, and the Rain-gauge, including for a portion of the time a series of Magnetical observations.

In the volume of "Washington Astronomical and Meteorological Observations," for 1861, occurs the following announcement: "The meteorological observations made between July 1, 1842, and January 1, 1861, will be published in separate volumes as rapidly as they can be prepared for the press;"—but the pressure of other duties during the late war prevented the prosecution of this scheme, and though a portion of the work was transcribed from the original records, and partially prepared for the press, no investigation of the character of these observations was attempted until 1867.

In this investigation it was proposed, first, to ascertain, if possible, the adopted methods of observation from 1842 to 1861—second, to learn how far the observations were made in accordance with the adopted plan, and third, to determine the character of the several series of observations.

1°. The Barometer, by Newman, was placed against the northern wall of the northwest room on the first floor of the main building, the cistern about three feet from the floor—nearly in the same position occupied by it since 1861—and the hours of observation were fixed at 0h., 2h., 3h., 4h., 6h., 8h., 9h., 10h., 12h., 14h., 15h., 16h., 18h., 20h., 21h., and 22h., mean time.

The principal Thermometers used were a dry bulb and a wet bulb, though a sun thermometer and a radiating thermometer were occasionally employed. There was no fixed place for the dry and the wet bulb thermometers. During a portion of the day they were placed against the southern wall of the main building a few feet west of the western wall of the south wing, and the remainder of the time they were suspended from the northern wall of the east wing, about six feet from the main building. The hours of observation were the same as for the Barometer. The Rain-gauge was placed about 60 feet south of the southwest corner of the main building, the top of the receiving cylinder about forty inches from the surface of the ground.

2°. From the observations and notes in the observing books, and the testimony of observers and other officers attached to the Observatory from time to time, it is evident that many of the so-called observations, with the barometer and the thermometers, were mere interpolations—especially those recorded as made during the night—and when the records represented the *true* indications of the various instruments the observations were frequently made at such irregular intervals as to greatly impair their value.

In many cases notes are appended to the observations of the thermometers, showing that the sun had shone on the bulbs of the wet and dry bulb thermometers for several minutes before the readings were made, and frequently both thermometers remained on the southern wall of the building during the entire day.

From the same testimony it is evident that the indications of the Rain-gauge were more carefully observed than those of the other instruments, probably from the fact that no more than one observation per day was required; and with the exception of the years 1849, 1850, and 1851, the observations seem to have been made in accordance with the original plan.

3°. It is plain that the only conclusion to be deduced from the foregoing facts is that, as records of real meteorological phenomena, the observations with the Barometer and the Thermometers from July 1, 1842, to January 1, 1861, are simply worthless. It is not denied that many of the observations, perhaps those for entire months, are correct, but it is impracticable, if not impossible, to eliminate them from the mass of error with which they are surrounded, for, if found they would be valuable only as curiosities.

The amount of rain-fall seems to have been carefully noted except for 1849, 1850 and 1851, and the tabulated amounts have been carefully collected and partially discussed elsewhere in this paper.

After the late Captain J. M. Gilliss, United States Navy, became Superintendent in 1861, the meteorological observations were made with greater care, and a series of comparisons were made to ascertain the errors of the thermometers.

Early in 1862, the hours of observation were changed to 0h., 3h., 6h., 9h., 12h., 15h., 18h., and 21h.; and the thermometers were placed in a small octagonal wooden building, designed for their special protection, situated about sixty feet south of the southwest corner of the main building. Since that date the observations with the Barometer, Thermometers, and Rain-gauge, have been made with great care every three hours, except in rare cases when the observer has been unavoidably called away by other duties. Since a portion of the observations with the barometer and thermometer in 1861, are deemed unreliable, all the data for that year depending on those instruments have been omitted from the following tables, leaving for further discussion the observations with the barometer and thermometer from January 1, 1862, to January 1, 1867, and the amount of rain-fall from January 1, 1843, to January 1, 1867, omitting the years 1849, 1850, and 1851.

THE BAROMETER.

The barometer in daily use from January 1, 1862, to January 1, 1867, was made by Newman, of London. Its cistern and tube are of glass. The internal diameter of the former is 3.0 inches, and of the latter 0.532 inch.

The original tube was 0.580 inch in diameter, but in 1853 it was ascertained that it had been injured, and it was removed and the present one inserted in its place by Würdemann, of Washington. The cistern cap rests in a cylindrical box of bronzed metal five inches deep, the surface of the mercury being visible through slits near the top of the box. The upper end of the tube is held in the arch of a double metallic frame, which is secured in the cap of the box. Pivots at the bottom of the box and top of the arch rest in the sockets of heavy brackets that project from a substantial mahogany board. Three equidistant horizontal screws act against the lower pivot to effect the vertical adjustment of the tube. The scale by which the height of the mercury column is read is attached to a brass rod within one of the upright frames, and is movable by a slow motion screw. It is silvered and divided to 0.05 inch, but by means of a vernier may be read to 0.002 inch.

There is an ivory point at its lower extremity and within the cistern, and the scale is in adjustment for use when the point and its image in the mercury are in apparent contact.

The temperature of the mercury within the cistern is shown by a small ivory scale thermometer fitted within the other tube-sustaining frame, its bulb passing below the surface of the mercury. The divisions of the thermometric scale are to 1°.0 and are correct within less than the probable error of an observation.

The barometer was placed during the period of five years between two north windows of the northwest room on the first floor of the building, its cistern 103 feet above mean half-tide of the Potomac river.

During the year 1864 several series of comparisons were made with the Observatory standard barometer, made by James Green of New York, on February 27, April 1, May 2, May 31, July 6, August 1, September 1, October 8, and December 1, from which it was shown that all observations with Newman's barometer require a correction of +0.005 inch.

This correction derived from comparisons in nearly every month in the year is adopted as best representing the error of the instrument, and has been applied to all the observations from which the following data are derived. When observations were omitted, the observed monthly means were corrected by interpolating the missing observations by means of a provisional formula, similar to the one in note A, when there was no local disturbance; but when such abnormal influences prevailed, the interpolations were made with reference only to the immediate disturbing cause. Each observation has been reduced to 32° Fahrenheit by means of Guyot's tables, but no correction has been applied for capillarity or for the height of the cistern above the level of the sea. Tables I, II, III, IV, and V, show the monthly means of pressure at the hours of observation for each year:

TABLE I.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
1862.	in.	in.	in.	in.	in.	in.	in.	in.
January	30.017	30.019	30.027	30.078	30.034	29.994	30.015	30.036
February	29.983	29.984	29.980	30.012	29.977	29.954	29.977	29.969
March	29.814	29.819	29.833	29.858	29.836	29.790	29.794	29.823
April	30.061	30.060	30.080	30.100	30.072	30.028	30.028	30.055
May	29.894	29.893	29.915	29.929	29.906	29.869	29.854	29.884
June	29.861	29.863	29.876	29.881	29.870	29.836	29.830	29.851
July	29.872	29.871	29.888	29.904	29.891	29.856	29.852	29.873
August	29.961	29.967	29.990	30.007	29.984	29.940	29.930	29.959
September	30.010	30.008	30.031	30.050	30.027	29.987	29.989	30.015
October	29.986	29.985	30.004	30.030	29.999	29.958	29.968	29.991
November	29.996	29.993	30.003	30.030	29.989	29.972	29.990	30.002
December	30.054	30.053	30.063	30.093	30.060	30.029	30.063	30.074

TABLE II.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
1863.	in.	in.	in.	in.	in.	in.	in.	in.
January	30.015	30.017	30.024	30.063	30.023	29.989	30.003	30.017
February	30.140	30.124	30.136	30.157	30.128	30.094	30.110	30.136
March	30.001	29.983	29.996	30.018	29.994	29.952	29.968	29.999
April	29.905	29.894	29.912	29.927	29.906	29.874	29.880	29.903
May	29.902	29.901	29.925	29.931	29.912	29.867	29.855	29.893
June	29.888	29.884	29.898	29.917	29.899	29.866	29.862	29.897
July	29.914	29.872	29.915	29.938	29.930	29.896	29.886	29.917
August	29.969	29.967	29.986	30.006	29.994	29.947	29.950	29.973
September	30.055	30.056	30.072	30.085	30.062	30.030	30.016	30.049
October	30.009	30.028	30.039	30.069	30.042	39.998	30.009	30.041
November	29.991	29.995	30.008	30.034	29.991	29.963	29.983	30.007
December	30.133	30.123	30.121	30.144	30.116	30.082	30.103	30.121

TABLE III.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
1864.	in.	in.	in.	in.	in.	in.	in.	in.
January	30.014	30.013	30.008	30.040	30.011	29.990	30.023	30.043
February	29.915	29.904	29.907	29.926	29.899	29.867	29.891	29.917
March	29.839	29.837	29.855	29.873	29.837	29.785	29.792	29.821
April	29.861	29.854	29.869	29.916	29.860	29.824	29.832	29.867
May	29.775	29.779	29.797	29.806	29.785	29.772	29.766	29.810
June	29.952	29.956	29.976	29.984	29.977	29.933	29.926	29.950
July	29.938	29.938	29.957	29.967	29.950	29.914	29.905	29.943
August	29.861	29.856	29.877	29.895	29.876	29.839	29.835	29.867
September	29.938	29.932	29.951	29.972	29.948	29.914	29.917	29.942
October	29.903	29.867	29.879	29.904	29.872	29.840	29.854	29.875
November	29.999	29.994	30.001	30.027	29.992	29.970	29.994	30.004
December	29.920	29.926	29.927	29.955	29.908	29.893	29.914	29.924

TABLE IV.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
1865.	in.	in.	in.	in.	in.	in.	in.	in.
January	29.982	29.987	29.990	30.021	29.990	29.963	29.970	29.988
February	30.035	30.028	30.032	30.059	30.043	30.001	30.018	30.031
March	29.973	29.964	29.968	29.994	29.973	29.924	29.937	29.954
April	30.000	29.999	30.010	30.062	30.031	29.984	29.990	30.026
May	29.858	29.859	29.877	29.893	29.871	29.834	29.842	29.869
June	29.985	29.975	29.995	30.012	29.999	29.959	29.951	29.977
July	29.906	29.905	29.931	29.946	29.942	29.912	29.894	29.925
August	29.976	29.971	29.994	30.017	29.996	29.951	29.944	29.972
September	30.048	30.046	30.067	30.077	30.051	30.005	30.003	30.027
October	29.912	29.911	29.933	29.958	29.928	29.899	29.902	29.926
November	30.014	30.010	30.024	30.058	30.017	29.984	29.983	30.039
December	30.035	30.032	30.048	30.101	30.066	30.047	30.054	30.070

TABLE V.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
1866.	in.	in.	in.	in.	in.	in.	in.	in.
January	30.094	30.092	30.094	30.154	30.124	30.097	30.075	30.093
February	30.099	30.105	30.115	30.174	30.132	30.082	30.068	30.110
March	30.022	30.005	30.026	30.050	30.010	29.960	29.972	29.996
April	29.941	29.942	29.964	29.985	29.953	29.920	29.908	29.939
May	29.780	29.774	29.801	29.814	29.789	29.776	29.740	29.777
June	29.877	29.871	29.892	29.901	29.882	29.846	29.844	29.876
July	29.925	29.926	29.945	29.963	29.944	29.905	29.891	29.918
August	29.888	29.882	29.896	29.911	29.888	29.850	20.856	29.860
September	29.958	29.954	29.968	29.984	29.948	29.924	29.932	29.959
October	30.018	30.020	30.029	30.051	30.019	29.991	30.010	30.028
November	30.012	30.009	30.023	30.051	30.016	29.986	30.002	30.007
December	30.020	30.026	30.014	30.058	30.001	29.998	30.021	30.027

The following table shows the mean pressure for each month as deduced from the preceding tables, and also the mean pressure for the year at the hours of observation :

TABLE VI.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	in.	in.	in.	in.	in.	in.	in.	in.
January	30.0244	30.0256	30.0286	30.0712	30.0364	30.0066	30.0172	20.0354
February	30.0344	30.0290	30.0340	30.0656	30.0358	29.9996	30.0128	30.0326
March	29.9298	29.9216	29.9356	29.9586	29.9300	29.8822	29.8926	29.9126
April	29.9536	29.9498	29.9670	29.9980	29.9644	29.9260	29.9276	29.9580
May	29.8418	29.8412	29.8630	29.8746	25.8526	29.8236	29.8114	29.8466
June	29.9126	29.9098	29.9274	29.9390	29.9254	29.8880	29.8826	29.9102
July	29.9110	29.9024	29.9272	29.9436	29.9314	29.8966	29.8856	29.9152
August	29.9310	29.9286	29.9486	29.9672	29.9476	29.9054	29.9030	29.9262
September	30.0018	29.9992	30.0178	30.0336	30.0072	29.9720	29.9714	29.9984
October	29.9656	29.9622	29.9768	30.0024	29.9720	29.9372	29.9486	29.9722
November	30.0024	30.0002	30.0118	30.0400	30.0010	29.9750	29.9904	30.0118
December	30.0324	30.0320	30.0346	30.0702	30.0302	30.0098	30.0310	30.0432
Year	29.9617	29.9585	29.9727	29.9970	29.9695	29.9352	29.9395	29.9640

Since the diurnal fluctuation of the mercurial column depends almost entirely upon the action of the solar heat upon the earth and the atmosphere, it follows that this law of fluctuation will vary with the latitude, and will require an independent determination for each change in the latitude of the observing station.

In all cases where a limited number of observations are to be made, it is of the first importance that the observer should know when to observe, in order to learn the true mean, as well as the maximum and minimum pressure for the day from the least number of observations.

In order to determine the important law of fluctuation from the data in the preceding tables, the constants in the following formula were computed, from the data in the lower line of table VI, according to the method given in *Note A*, for finding the most probable values of the constants in the *periodic* formula, from eight equidistant observations in a cycle.

$$\chi=29.9623\,\textit{in.}+0.0186\,\textit{in.}\ \sin\,(\theta+303^{\circ}\ 39')+0.0175\,\textit{in.}\ \sin\,(2\,\theta+174^{\circ}\ 14')$$
$$+0.0016\,\textit{in.}\ \sin\,(3\theta+216^{\circ}\ 50')-0.0014\,\textit{in.}\ \sin\,(4\theta+90^{\circ}).$$

With this formula the pressure was computed for the hours on which the observations were made with the following results :

h.	Computed.	Observed.	C.— O.
	in.	in.	in.
0	29.9617	29.9617	0.0000
3	.9586	.9585	+ .0001
6	.9728	.9727	+ .0001
9	.9970	.9970	.0000
12	.9696	.9695	+ .0001
15	.9353	.9352	+ .0001
18	.9396	.9395	+ .0001
21	29.9640	29.9640	0.0000

These differences are less than the smallest difference observable with the vernier of the instrument, and since this formula so well represents the observed variation it has been employed in computing the height of the mercurial column at intervals of fifteen minutes during the period of twenty-four hours, and in determining the time of maximum and minimum height.

The following table exhibits the computed pressure for each fifteen minutes of the day :

TABLE VII.

h. m.	in.	h. m.	in.	h. m.	in.	h. m.	in.
0 0	29.9617	6 0	29.9728	12 0	29.9696	18 0	29.9396
15	.9610	15	.9752	15	.9658	15	.9416
30	.9605	30	.9778	30	.9621	30	.9440
45	.9600	45	.9805	45	.9586	45	.9461
1 0	.9595	7 0	.9832	13 0	.9551	19 0	.9486
15	.9590	15	.9858	15	.9518	15	.9510
30	.9588	30	.9882	30	.9488	30	.9534
45	.9585	45	.9907	45	.9459	45	.9557
2 0	.9583	8 0	.9926	14 0	.9433	20 0	.9578
15	.9582	15	.9943	15	.9409	15	.9597
30	.9583	30	.9956	30	.9387	30	.9614
45	.9583	45	.9967	45	.9369	45	.9629
3 0	.9586	9 0	.9970	15 0	.9353	21 0	.9640
15	.9588	15	.9970	15	.9340	15	.9650
30	.9590	30	.9964	30	.9330	30	.9656
45	.9595	45	.9954	45	.9323	45	.9660
4 0	.9602	10 0	.9939	16 0	.9318	22 0	.9661
15	.9610	15	.9919	15	.9318	15	.9661
30	.9620	30	.9896	30	.9320	30	.9656
45	.9633	45	.9864	45	.9325	45	.9652
5 0	.9648	11 0	.9837	17 0	.9334	23 0	.9645
15	.9665	15	.9803	15	.9345	15	.9639
30	.9683	30	.9769	30	.9359	30	.9633
45	29.9704	45	29.9731	45	29.9376	45	29.9625

TABLE XIV. JULY.

$\chi = 29.9141 + .0187 \sin(\theta + 286^\circ 7') + .0167 \sin(2\theta + 63^\circ 45') + .0044 \sin(3\theta + 58^\circ 49'.)$

Hour.	Computed.	Observed.	C. — O.
	in.	in.	in.
0	29.9114	29.9110	+ 0.0004
1	.9048		
2	.9005		
3	.9020	29.9024	— .0004
4	.9082		
5	.9175		
6	.9274	29.9272	+ .0002
7	.9357		
8	.9410		
9	.9432	29.9436	— .0004
10	.9430		
11	.9387		
12	.9316	29.9314	+ .0002
13	.9212		
14	.9091		
15	.8962	29.8966	— .0004
16	.8866		
17	.8829		
18	.8860	29.8856	+ .0004
19	.8947		
20	.9058		
21	.9150	29.9152	— 0.0002
22	.9191		
23	29.9173		

TABLE XV. AUGUST.

$\chi = 29.9322 + .0238 \sin(\theta + 297^\circ 12') + .0163 \sin(2\theta + 65^\circ 20') + .0010 \sin(3\theta + 132^\circ 57'.)$

Hour.	Computed.	Observed.	C. — O.
	in.	in.	in.
0	29.9307	29.9310	— 0.0003
1	.9288		
2	.9278		
3	.9290	29.9286	+ .0004
4	.9314		
5	.9396		
6	.9481	29.9486	— .0005
7	.9568		
8	.9639		
9	.9675	29.9672	+ .0003
10	.9660		
11	.9591		
12	.9473	29.9476	— .0003
13	.9326		
14	.9178		
15	.9058	29.9054	+ .0004
16	.9010		
17	.8982		
18	.9027	29.9030	— .0003
19	.9106		
20	.9193		
21	.9265	29.9262	+ 0.0003
22	.9308		
23	29.9319		

TABLE XVI. SEPTEMBER.

$\chi = 30.0002 + 0228 \sin(\theta + 307^\circ 52') + .0160 \sin(2\theta + 71^\circ 47') + .0005 \sin(3\theta + 39^\circ 28'.)$

Hour.	Computed.	Observed.	C. — O.
	in.	in.	in.
0	30 0018	30.0018	0.0000
1	29.9994		
2	.9982		
3	29.9992	29.9992	.0000
4	30.0030		
5	.0094		
6	.0177	30.0178	— .0001
7	.0267		
8	.0322		
9	.0337	30.0336	+ .0001
10	.0295		
11	.0200		
12	30.0074	30.0072	+ .0002
13	29.9933		
14	.9814		
15	.9720	29.9720	.0000
16	.9666		
17	.9666		
18	.9715	29.9714	+ .0001
19	.9807		
20	.9902		
21	29.9983	29.9984	— 0.0001
22	30.0029		
23	30.0036		

TABLE XVII. OCTOBER.

$\chi = 29.9671 + .0170 \sin(\theta + 306^\circ 24') + 0190 \sin(2\theta + 80^\circ 56') + .0028 \sin(3\theta + 210^\circ 42'.)$

Hour.	Computed.	Observed.	C. — O.
	in.	in.	in.
0	29.9657	29.9656	+ 0.0001
1	.9630		
2	.9619		
3	.9620	29.9622	— .0002
4	.9640		
5	.9687		
6	.9770	29.9768	+ .0002
7	.9878		
8	29.9975		
9	30.0022	30.0024	— .0002
10	29.9987		
11	.9877		
12	.9721	29.9720	+ .0001
13	.9564		
14	.9441		
15	.9370	29.9372	— .0002
16	.9360		
17	.9403		
18	.9488	29.9486	+ .0002
19	.9588		
20	.9673		
21	.9720	29.9722	— 0.0002
22	.9721		
23	29.9693		

TABLE XVIII. NOVEMBER.

$$\chi = 30.0041 + .0148 \sin(\theta + 314^\circ\ 19') + .0192 \sin(2\theta + 89^\circ\ 6') + .0049 \sin(3\theta + 237^\circ\ 10'.)$$

Hour.	Computed.	Observed.	C. — O.
	in.	in.	in.
0	30.0023	30.0024	— 0.0001
1	.0006		
2	.0003		
3	.0003	30.0002	+ .0001
4	.0006		
5	.0036		
6	.0117	30.0118	— .0001
7	.0240		
8	.0357		
9	.0402	30.0400	+ .0002
10	.0339		
11	.0189		
12	30.0009	30.0010	— .0001
13	29.9862		
14	.9777		
15	.9751	29.9750	+ .0001
16	.9768		
17	.9820		
18	29.9903	29.9904	— .0001
19	30.0000		
20	.0083		
21	.0120	30.0118	+ 0.0002
22	.0107		
23	30.0063		

TABLE XIX. DECEMBER.

$$\chi = 30.0354 + .0096 \sin(\theta + 313^\circ\ 12') + .0179 \sin(2\theta + 92^\circ\ 24') + .0079 \sin(3\theta + 235^\circ\ 9'.)$$

Hour.	Computed.	Observed.	C. — O.
	in.	in.	in.
0	30.0325	30.0324	+ 0.0001
1	.0329		
2	.0334		
3	.0319	30.0320	— .0001
4	.0287		
5	.0282		
6	.0346	30.0346	.0000
7	.0481		
8	.0628		
9	.0701	30.0702	— .0001
10	.0650		
11	.0494		
12	.0303	30.0302	+ .0001
13	.0155		
14	.0088		
15	.0097	30.0098	— .0001
16	.0151		
17	.0228		
18	.0310	30.0310	.0000
19	.0386		
20	.0431		
21	.0430	30.0432	— 0.0002
22	.0392		
23	30.0348		

Determining the maxima and minima of the curves represented by the equations from which the last twelve tables were computed, we have the results shown in the following table :

TABLE XX.

Month.	First minimum.		Second minimum.		First maximum.		Second maximum.	
	Time.	Pressure.	Time.	Pressure.	Time.	Pressure.	Time.	Pressure.
	h. m.	in.	h. m.	in.	h. m.	in.	h. m.	in.
January	3 50	30.0280	15 10	30.0064	9 35	30.0714	20 50	30.0354
February	4 10	30.0263	15 25	29.9986	9 20	30.0660	23 10	30.0347
March	3 30	29.9214	15 55	.8796	9 20	29.9582	23 40	29.9300
April	2 50	.9495	16 25	.9198	9 15	.9982	22 25	.9606
May	2 0	.8374	16 50	.8090	8 0	.8746	22 20	.8509
June	1 50	.9082	16 50	.8779	9 10	.9394	22 35	.9152
July	2 0	.9005	17 0	.8829	9 15	.9434	22 10	.9192
August	2 10	.9277	16 35	.8978	9 5	29.9676	22 50	29.9319
September	2 15	.9981	16 30	.9660	8 45	30.0338	22 50	30.0036
October	2 35	29.9617	15 35	.9353	9 5	.0024	21 20	29.9722
November	3 0	30.0003	15 0	29.9751	9 0	.0402	21 30	30.0122
December	4 10	30.0280	14 50	30.0084	9 5	30.0702	19 50	30.0432

Although this table shows the necessity of making more frequent observations in order to determine the minor fluctuations, yet it as plainly indicates the influence of the solar heat on the motion of the mercurial column, more especially in the column giving the time of minimum pressure.

In tables VIII to XIX, inclusive, it is shown in every instance that the computed pressures differ from the observed by a quantity less than any observable error, and in no instance does the error amount to 0.001 in. These errors are too small to be considered in determining the maxima and minima for practical use, and they have been therefore entirely neglected in the preparation of table XX.

The most convenient hours for observing in each month, in order to obtain the mean pressure from three observations, and also from a single observation, are given below :

TABLE XXI.

Month.	Triple observations.						Single observations.	
	h.	h.	h.	h.	h.	h.	h. m.	h. m.
January	9	13	16	8	13	18	12 30	20 0
February	8	12	16	9	13	17	12 20	21 0
March	9	13	18	8	12	16	12 25	21 20
April	8	13	17	9	13	17	12 35	21 0
May	9	13	18	8	13	18	13 0	21 0
June	9	13	16	8	13	18	13 10	21 10
July	8	13	17	9	13 30m.	18	13 30	21 0
August	8	13	16	9	13	17	13 0	23 0
September	9	13	18	7	12	17	12 30	21 30
October	8	13	18	9	13	17	12 20	20 0
November	7	12	17	8	13	18	12 0	19 30
December	10	14	18	9	13	17	11 55	18 10

These times are not rigorously exact, but since observations are more likely to be regularly made at even hours, the above list is recommended as the most convenient, and at the same time sufficiently accurate, for in no instance does the error amount to the smallest quantity measurable by the vernier.

ANNUAL FLUCTUATION.

From table VI the following values of mean pressure for each month were obtained :

	in.		*in.*
January,	30.0307.	July,	29.9141.
February,	30.0305.	August,	29.9322.
March,	29.9211.	September,	30.0002.
April,	29.9556.	October,	29.9671.
May,	29.8444.	November,	30.0041.
June,	29.9119.	December,	30.0354.

As the above values represent the mean pressure for the middle of each month, the interval between two consecutive epochs will be, on account of the number of days in the calendar months, unequal, and the following table shows the mean observed pressure, the correction for inequality of intervals,* and the corrected pressure.

TABLE XXII.

Month.	Observed.	Correction.	Corrected pressure.
	in.	in.	in.
January	30. 0307	0. 0000	30. 0307
February	30. 0305	— . 0030	30. 0275
March	29. 9211	— . 0043	29. 9168
April	29. 9556	— . 0021	29. 9535
May	29. 8444	— . 0010	29. 8434
June	29. 9119	+ . 0012	29. 9131
July	29. 9141	+ . 0003	29. 9144
August	29. 9322	+ . 0010	29. 9332
September	30. 0002	— . 0001	30. 0001
October	29. 9671	— . 0004	29. 9667
November	30. 0041	+ . 0008	30. 0049
December	30. 0354	+ 0. 0002	30. 0356

From the quantities representing the corrected pressure were computed the constants in the following formula. (See note A.)

$$\begin{aligned}\chi = 29.9617 &+ .0697 \sin(\theta + 94^\circ\ 53') + .0199 \sin(2\theta + 354^\circ\ 16') \\ &+ .0068 \sin(3\theta + 21^\circ\ 29') + .0094 \sin(4\theta + 30^\circ\ 15') \\ &+ .0314 \sin(5\theta + 200^\circ\ 4') + .0099 \sin(6\theta + 90^\circ\ 0').\end{aligned}$$

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* See Silliman's Journal, vol. 42, page 155.

From this equation the mean pressure for each day of the year has been computed and is shown in—

TABLE XXIII.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1	30.0196	30.0534	29.9607	29.9376	29.9067	29.8546	29.9365	29.9051	29.9772	29.9935	29.9618	30.0465
2	.0194	.0532	.9558	.9397	.9024	.8577	.9363	.9054	.9806	.9919	.9632	.0482
3	.0192	.0530	.9514	.9419	.8975	.8600	.9359	.9060	.9832	.9901	.9646	.0501
4	.0193	.0524	.9469	.9441	.8929	.8643	.9355	.9067	.9856	.9884	.9663	.0517
5	.0196	.0513	.9428	.9460	.8873	.8676	.9351	.9076	.9879	.9867	.9682	.0528
6	.0200	.0500	.9391	.9476	.8840	.8713	.9344	.9085	.9901	.9847	.9705	.0537
7	.0206	.0486	.9355	.9493	.8795	.8755	.9335	.9095	.9921	.9827	.9728	.0542
8	.0214	.0470	.9320	.9507	.8753	.8789	.9323	.9112	.9939	.9807	.9754	.0545
9	.0224	.0448	.9290	.9522	.8710	.8826	.9313	.9127	.9957	.9788	.9779	.0547
10	.0235	.0425	.9266	.9528	.8671	.8866	.9299	.9143	.9971	.9766	.9808	.0546
11	.0246	.0398	.9241	.9536	.8632	.8903	.9284	.9159	.9984	.9749	.9837	.0544
12	.0261	.0369	.9220	.9537	.8597	.8942	.9269	.0179	29.9998	.9731	.9870	.0537
13	.0274	.0338	.9203	.9540	.8563	.8981	.9254	.9199	30.0013	.9712	.9903	.0529
14	.0290	.0302	.9189	.9538	.8533	.9017	.9238	.9221	.0019	.9696	.9936	.0519
15	.0307	.0265	.9177	.9532	.8503	.9053	.9221	.9244	.0026	.9680	29.9971	.0505
16	.0324	.0225	.9169	.9525	.8478	.9086	.9203	.9271	.0032	.9663	30.0004	.0490
17	.0341	.0183	.9164	.9515	.8458	.9118	.9185	.9297	.0038	.9647	.0042	.0476
18	.0362	.0140	.9163	.9499	.8439	.9150	.9168	.9326	.0045	.9633	.0076	.0461
19	.0377	.0098	.9165	.9480	.8426	.9183	.9150	.9354	.0052	.9620	.0111	.0440
20	.0396	.0048	.9166	.9459	.8416	.9211	.9134	.9385	.0050	.9611	.0145	.0420
21	.0415	30.0000	.9174	.9436	.8408	.9237	.9118	.9416	.0039	.9601	.0180	.0401
22	.0432	29.9950	.9183	.9410	.8405	.9261	.9105	.9446	.0034	.9594	.0215	.0380
23	.0447	.9901	.9195	.9382	.8405	.9282	.9091	.9475	.0028	.9587	.0248	.0368
24	.0463	.9851	.9209	.9349	.8408	.9304	.9079	.9501	.0021	.9582	.0285	.0335
25	.0478	.9803	.9227	.9315	.8416	.9319	.9078	.9527	.0013	.9579	.0315	.0314
26	.0493	.9751	.9245	.9279	.8425	.9333	.9070	.9558	30.0004	.9577	.0345	.0292
27	.0506	.9701	.9264	.9241	.8439	.9344	.9062	.9589	29.9992	.9579	.0372	.0273
28	.0515	29.9653	.9284	.9199	.8456	.9354	.9055	.9621	.9980	.9580	.0398	.0250
29	.0523	. . .	.9307	.9158	.8473	.9358	.9050	.9659	.9966	.9585	.0417	.0232
30	.0528	. . .	.9329	29.9115	.8494	29.9363	.0049	.9690	29.9952	.9599	30.0442	.0212
31	30.0533	. . .	29.9351	. . .	29.8520	. . .	29.9048	29.9728	. . .	29.9609	. . .	30.0200

From table XXIII we find that the maximum pressure occurs on the 9th of December, and the minimum on the 22d and 23d of May.

From the data in table XXIII, the barometric curve, (No. 1,) in plate II, was plotted, showing the mean annual fluctuation of the mercurial column, or its mean height for each day in the year.

From this curve we also find that the times of maxima occur on February 1, April 13, July 1, September 19, and December 9; and the times of minima on January 3, March 18, May 22 and 23, July 31, and October 26.

The greatest pressure during the period of five years occurred on the 8th of January, 1866, at 9h. Reduced to 32° Fahrenheit, it was 30.966 in. The least pressure occurred on the 23d April, 1866, at 16h. Reduced to 32° Fahrenheit, it was 28.951 in., giving for the greatest range for the period 2.015 inches.

THE THERMOMETER.

The instrument in use from January 1, 1862, to December 31, 1866, inclusive, is a mercurial thermometer, made by James Green of New York, with a bulb 1.5 inch in length and 0.2 inch in diameter.

Its scale is of glass twelve inches long, 0.8 inch wide, and 0.1 inch thick. The bulb projects about one inch beyond the scale.

The divisions of the scale are engraved upon the glass to half degrees, from 30° to + 125° Fahrenheit. Each division is about 0.032 inch.

This thermometer was placed with the wet bulb and maximum and minimum thermometers in a small wooden building, about sixty feet south of the southwest corner of the main building. The form of this building is octagonal, each side being, on the outside, two feet five inches wide by six feet three inches high to the eaves. The walls are formed of two sections of lattice work, each section resembling a common window blind, with a space of three inches between the sections. Figure 1 represents a portion of a cross section of the wall. The walls terminate one foot above the grass.

The roof is made of tin, left bright on the under side, while the top is painted white. The ceiling is of thick plank, and between it and the roof there is a large open space that permits a very free circulation of air.

The door is on the north side and is constructed like the walls.

The Thermometer was suspended from a brass arm attached to a stout rod securely fastened in the ground beneath the building, the bulb about fifty inches from the grass.

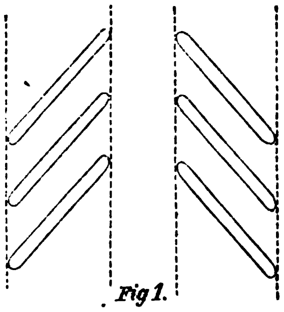


Fig 1.

A series of comparisons, extending through the greater part of the year 1863, were made with the Observatory standard thermometer, and the following corrections were obtained.

These corrections have been verified from time to time, and in 1866 they were adopted as the true corrections.

TABLE I.

Temp.	Correction.	Temp.	Correction.	Temp.	Correction.	Temp.	Correction.	Temp.	Correction.	Temp.	Correction.
°	°	°	°	°	°	°	°	°	°	°	°
24	− 0.2	36	+ 0.1	48	+ 0.2	60	+ 0.1	72	+ 0.1	84	+ 0.2
25	− .1	37	+ .1	49	+ .2	61	+ .1	73	.0	85	+ .3
26	.0	38	+ .1	50	.0	62	+ .1	74	.0	86	− .1
27	.0	39	+ .2	51	.0	63	+ .1	75	.0	87	− .2
28	.0	40	+ .2	52	.0	64	+ .1	76	+ .1	88	.0
29	.0	41	.0	53	.0	65	+ .2	77	+ .1	89	+ .2
30	.0	42	− .2	54	.0	66	+ .2	78	+ .2	90	+ .1
31	.0	43	− .3	55	.0	67	+ .2	79	+ .6	91	+ .2
32	+ .1	44	− .1	56	.0	68	+ .2	80	+ .1	92	+ .3
33	+ .1	45	.0	57	+ .1	69	+ .2	81	+ .1	93	+ .2
34	+ .1	46	+ .1	58	+ .1	70	+ .2	82	+ .1	94	+ 0.1
35	+ 0.1	47	+ 0.2	59	+ 0.1	71	+ 0.2	83	+ 0.1		

These corrections have been applied to all the observations.

Where observations were omitted the observed monthly means were corrected by interpolating the missing observations by the method employed in correcting the observations with the barometer.

Tables II, III, IV, V, and VI, show the corrected monthly means of temperature at the hours of observation during the period of five years.

TABLE II. 1862.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	°	°	°	°	°	°	°	°
January .	34.16	33.23	32.03	33.19	36.93	38.48	37.02	35.35
February .	33.88	33.30	33.13	34.82	38.77	40.08	37.43	35.10
March . .	38.37	36.91	35.57	40.00	45.43	47.03	44.81	41.35
April . .	46.66	45.19	44.47	50.84	55.40	56.76	54.06	49.68
May . .	59.11	56.62	57.34	65.85	71.06	71.13	67.87	62.28
June . .	62.76	60.95	61.03	68.89	74.14	75.41	72.72	65.74
July . .	68.82	67.37	66.63	73.94	79.35	80.10	77.38	70.55
August .	69.27	67.55	66.02	74.91	82.09	84.12	78.99	72.27
Septem'r .	63.58	61.83	60.70	67.90	76.51	78.39	71.40	65.87
October .	54.48	52.53	50.97	56.98	67.25	68.74	61.56	56.62
Novem'r .	42.01	40.40	39.43	42.76	50.60	50.87	45.55	43.48
Decem'r .	34.03	32.50	31.26	33.65	41.45	43.76	38.49	35.04

TABLE III. 1863.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	°	°	°	°	°	°	°	°
January .	34.44	33.73	32.68	34.89	43.71	43.11	38.59	36.29
February .	32.26	31.16	30.87	33.24	38.88	40.93	38.05	34.90
March .	34.83	33.12	32.80	36.49	41.02	43.38	41.03	37.00
April . .	45.14	42.75	41.58	47.71	53.26	54.98	52.63	47.82
May . .	57.64	55.23	54.49	64.95	71.64	74.26	69.36	62.17
June . .	63.99	62.35	62.02	69.92	75.88	77.47	73.66	67.35
July . .	70.53	69.62	69.54	75.04	79.65	81.09	77.75	72.50
August .	71.18	69.00	68.42	77.06	84.99	87.77	80.66	74.38
Septem'r .	59.11	57.39	56.26	63.20	72.66	75.27	67.44	61.82
October .	49.65	48.21	47.34	53.03	61.95	62.51	55.79	51.51
Novem'r .	43.72	41.93	40.99	44.80	53.26	54.66	48.15	45.11
Decem'r .	32.54	31.51	30.73	33.23	40.95	41.58	36.66	34.15

TABLE IV. 1864.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	°	°	°	°	°	°	°	°
January	29.71	28.50	27.82	30.15	39.36	41.83	36.33	32.41
February	32.82	30.86	29.71	34.12	41.40	44.05	38.33	35.03
March	36.12	34.40	33.18	38.46	44.49	46.19	43.33	39.02
April	45.95	43.89	43.05	51.01	55.69	57.34	54.67	49.39
May	60.57	58.18	57.75	66.92	73.34	75.68	70.56	64.30
June	64.51	61.49	61.57	71.81	78.64	80.66	76.69	68.19
July	70.41	68.13	67.25	76.70	86.02	87.70	83.80	74.93
August	72.98	71.19	70.39	77.25	84.21	86.04	80.56	74.54
Septem'r	61.65	59.99	58.90	61.93	72.13	74.12	67.39	63.44
October	50.22	48.04	46.63	53.06	62.09	62.62	55.71	52.18
Novem'r	41.34	40.30	39.81	43.23	50.22	50.72	45.79	43.10
Decem'r	33.66	32.60	31.67	33.68	38.40	39.47	37.19	34.27

TABLE V. 1865.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	°	°	°	°	°	°	°	°
January	25.46	24.03	23.15	25.76	31.08	32.15	29.48	27.66
February	29.82	28.57	27.64	30.72	37.00	38.54	34.48	31.53
March	43.92	42.43	40.99	46.55	52.92	55.43	50.97	47.21
April	51.55	49.47	49.07	56.13	61.79	63.84	59.47	54.54
May	58.21	56.32	55.63	63.99	69.65	71.66	67.85	61.75
June	70.08	68.60	68.52	75.62	81.79	82.79	78.58	72.77
July	70.88	69.17	69.11	76.81	81.15	83.06	80.10	73.28
August	68.49	67.06	66.28	73.63	80.67	81.85	78.02	71.13
Septem'r	67.75	66.10	64.86	72.78	81.90	83.64	75.75	70.36
October	50.18	48.13	46.76	55.04	61.55	64.77	56.80	51.64
Novem'r	41.62	40.00	38.73	43.49	52.59	54.05	47.35	43.72
Decem'r	36.18	35.41	34.07	36.34	40.94	42.07	38.23	36.62

TABLE VI. 1866.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	°	°	°	°	°	°	°	°
January	29.29	28.54	27.92	29.33	34.59	35.96	32.29	30.49
February	31.74	30.05	28.47	32.17	39.34	42.22	37.98	34.48
March	38.77	37.39	36.41	40.40	47.00	49.64	45.90	40.79
April	51.91	49.99	49.05	54.92	61.52	64.07	60.54	55.35
May	55.76	52.87	52.43	58.59	67.43	70.20	65.70	59.00
June	67.62	65.39	64.88	73.11	78.78	81.37	77.70	70.93
July	72.23	70.56	69.86	78.61	85.39	86.87	82.88	75.51
August	65.32	63.22	62.14	70.37	76.76	79.03	74.43	68.04
September	64.20	62.96	62.31	68.67	76.17	77.43	70.51	66.01
October	53.37	51.72	50.20	58.83	65.10	66.41	58.23	54.38
November	43.18	41.39	39.76	44.93	54.14	55.06	48.73	45.41
December	31.33	30.20	29.49	31.44	37.13	38.30	33.78	31.57

Table VII gives the mean results for each month, and for the entire year, at the hours of observation, and table VIII, formed from the data in table VII, gives the mean temperature for each month.

TABLE VII.

Month.	0h.	3h.	6h.	9h.	12h.	15h.	18h.	21h.
	°	°	°	°	°	°	°	°
January	30.61	29.61	28.72	30.66	37.13	38.31	34.74	32.44
February	32.10	30.79	29.96	33.01	30.08	41.16	37.25	34.21
March	38.40	36.85	35.79	40.38	46.17	48.33	45.21	41.07
April	48.24	46.26	45.44	52.12	57.53	59.40	56.27	51.36
May	58.26	55.84	55.53	64.06	70.62	72.59	68.27	61.90
June	65.79	63.75	63.60	71.87	77.85	79.54	75.87	68.99
July	70.57	68.97	68.47	76.22	82.31	83.76	80.38	73.35
August	69.45	67.62	66.65	74.64	81.74	83.76	78.53	72.07
September	63.26	61.65	60.61	70.90	75.87	77.77	70.50	65.50
October	51.58	49.73	48.38	55.39	63.59	65.01	57.62	53.57
November	42.37	40.80	39.74	43.84	52.16	53.01	47.11	44.16
December	33.55	32.44	31.44	33.67	39.77	41.04	36.87	34.33
Year	50.35	48.96	47.86	53.98	60.32	61.97	57.38	52.64

TABLE VIII.

Month.	Temp.	Month.	Temp.	Month.	Temp.
	°		°		°
January	32.78	May	63.38	September	68.26
February	34.70	June	70.91	October	55.57
March	41.52	July	75.50	November	45.40
April	52.08	August	74.31	December	35.39

From the data in the lower line of table VII, the constants for the following formula were computed. (See note A.)

$$\chi=54.15+6^{\circ}.78\sin(\theta+183^{\circ}\,30')+1^{\circ}.69\sin(2\theta+323^{\circ}\,21')+0^{\circ}.28\sin(3\theta+243^{\circ}\,58')$$

With this formula the temperature was computed for the hours on which the observations were made, with the following results :

TABLE IX.

Hour.	Computed temp.	Observed temp.	C. — O.
h.	°	°	°
0	50.35	50.35	0.00
3	48.69	48.69	.00
6	47.86	47.86	.00
9	53.97	53.98	— .01
12	60.33	60.32	+ .01
15	61.97	61.97	.00
18	57.38	57.38	.00
21	52.65	52.64	+ 0.01

As the above equation represents very accurately the observed temperatures, it has been employed in computing the temperature at intervals of fifteen minutes during the day, in order to exhibit the diurnal fluctuation for the whole year, and to determine, as accurately as possible from the nature of the data employed, the proper hours for making a reliable series of observations, extending through one or several years.

TABLE X.

Hour.	Com. temp.	Hour.	Com. temp.	Hour.	Com. temp.	Hour.	Com. temp.	Hour.	Com. temp.	Hour.	Com. temp.
h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
0 0	50.35	4 0	47.91	8 0	51.42	12 0	60.33	16 0	60.95	20 0	53.94
15	50.25	15	47.75	15	52.04	15	60.69	15	60.57	15	53.60
30	50.14	30	47.62	30	52.70	30	61.00	30	60.20	30	53.26
45	50.03	45	47.54	45	53.33	45	61.31	45	59.76	45	52.95
1 0	49.93	5 0	47.50	9 0	53.97	13 0	61.57	17 0	59.30	21 0	52.65
15	49.82	15	47.49	15	54.61	15	61.78	15	58.83	15	52.37
30	49.69	30	47.55	30	55.25	30	61.95	30	58.35	30	52.11
45	49.56	45	47.69	45	55.87	45	62.08	45	57.87	45	51.85
2 0	49.40	6 0	47.86	10 0	56.44	14 0	62.18	18 0	57.38	22 0	51.62
15	49.24	15	48.12	15	57.03	15	62.20	15	56.90	15	51.41
30	49.07	30	48.43	30	57.57	30	62.17	30	56.43	30	51.21
45	48.87	45	48.78	45	58.10	45	62.09	45	56.00	45	51.04
3 0	48.69	7 0	49.25	11 0	58.60	15 0	61.97	19 0	55.53	23 0	50.88
15	48.47	15	49.73	15	59.07	15.	61.79	15	55.11	15	50.73
30	48.28	30	50.25	30	59.52	30	61.56	30	54.71	30	50.58
45	48.08	45	50.82	45	59.93	45	61.28	45	54.30	45	50.47

From the above equation we find that the maximum mean daily temperature for the year is 62°.20, and occurs at 14h. 15m., and that the minimum is 47°.48, and occurs at 5h. 10.

From the data in table X, the temperature curve, (No. 2,) in plate I, was plotted, showing the mean daily temperature at each interval of fifteen minutes during the day.

As the results from this table show the diurnal fluctuation only for a cycle of twelve months, tables XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, and XXII, have been computed for each hour from the data in the first twelve lines of table VII, to exhibit the daily variation of temperature in each month, and to show the motion of the maximum and minimum points throughout the year.

TABLE XI. JANUARY.

$$\chi = 32^\circ.78 + 4^\circ.40 \sin(\theta + 75^\circ\,22') + 1^\circ.61 \sin(2\,\theta + 311^\circ\,36') + 0^\circ.53 \sin(3\,\theta + 94^\circ\,27'.)$$

Hour.	Computed temp.	Observed temp.	C.— O.
	°	°	°
0	30.60	30.61	− 0.01
1	30.16		
2	29.88		
3	29.64	29.61	+ .03
4	29.36		
5	29.02		
6	28.70	28.72	− .02
7	28.71		
8	29.32		
9	30.69	30.66	+ .03
10	22.72		
11	35.02		
12	37.10	37.13	− .03
13	38.46		
14	38.84		
15	38.32	38.31	+ .01
16	37.22		
17	35.90		
18	34.72	34.74	− .02
19	33.79		
20	33.08		
21	32.47	32.44	+ 0.03
22	31.82		
23	31.18		

TABLE XII. FEBRUARY.

$$\chi = 34^\circ.70 + 5^\circ.13 \sin(\theta + 176^\circ\,2') + 1^\circ.54 \sin(2\,\theta + 310^\circ\,0') + 0^\circ.25 \sin(3\,\theta + 74^\circ\,0'.)$$

Hour.	Computed temp.	Observed temp.	C.— O.
	°	°	°
0	32.11	32.10	+ 0.01
1	31.61		
2	31.22		
3	30.79	30.79	.00
4	30.37		
5	30.01		
6	29.97	29.96	+ .01
7	30.40		
8	31.34		
9	33.02	33.01	+ .01
10	34.98		
11	37.10		
12	39.07	39.08	− .01
13	40.59		
14	41.34		
15	42.15	41.16	− .01
16	40.19		
17	38.75		
18	37.27	37.25	+ .02
19	36.00		
20	35.02		
21	34.20	34.21	− 0.01
22	33.46		
23	32.74		

TABLE XIII. MARCH.

$$\chi = 41^\circ.52 + 5^\circ.93 \sin(\theta + 175^\circ\,30') + 1^\circ.29 \sin(2\,\theta + 313^\circ\,45') + 0^\circ.21 \sin(3\,\theta + 215^\circ\,17'.)$$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	38.40	38.40	0.00
1	37.93		
2	37.45		
3	36.84	36.85	− .01
4	36.15		
5	35.68		
6	35.78	35.79	− .01
7	36.69		
8	38.31		
9	40.38	40.38	.00
10	42.51		
11	44.49		
12	46.16	46.17	− .01
13	47.47		
14	48.21		
15	48.32	48.33	− .01
16	47.73		
17	46.62		
18	45.22	45.21	+ .01
19	43.75		
20	42.35		
21	41.06	41.07	− 0.01
22	39.93		
23	39.05		

TABLE XIV. APRIL.

$$\chi = 52^\circ.08 + 6^\circ.89 \sin(\theta + 179^\circ\,19') + 1^\circ.15 \sin(2\,\theta + 331^\circ\,46') + 0^\circ.53 \sin(3\,\theta + 239^\circ\,36'.)$$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	48.22	48.24	− 0.02
1	47.87		
2	47.03		
3	46.22	46.26	− .04
4	45.34		
5	44.91		
6	45.41	45.44	− .03
7	47.03		
8	49.45		
9	52.11	52.12	− .01
10	54.40		
11	56.26		
12	57.55	57.53	+ .02
13	58.59		
14	59.28		
15	59.45	59.40	+ .05
16	58.96		
17	58.23		
18	56.32	56.27	+ .05
19	54.63		
20	52.95		
21	51.39	51.36	+ 0.03
22	50.02		
23	48.96		

TABLE XV. MAY.

$\chi = 63^\circ.38 + 8^\circ.63 \sin(\theta + 183^\circ 8') + 1^\circ.41 \sin(2\theta + 334^\circ 4') + 0^\circ.66 \sin(3\theta + 247^\circ 42'.)$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	58.26	58.26	0.00
1	57.60		
2	56.81		
3	55.85	55.84	+ .01
4	54.94		
5	54.66		
6	55.53	55.53	.00
7	57.72		
8	60.78		
9	64.05	64.06	— .01
10	66.86		
11	69.03		
12	70.62	70.62	.00
13	71.78		
14	72.49		
15	72.57	72.59	— .02
16	71.84		
17	70.88		
18	68.27	68.27	.00
19	66.02		
20	64.14		
21	61.89	61.90	— 0.01
22	60.28		
23	59.11		

TABLE XVI. JUNE.

$\chi = 70^\circ.91 + 8^\circ.28 \sin(\theta + 184^\circ 45') + 1^\circ.21 \sin(2\theta + 329^\circ 46') + 0^\circ.84 \sin(3\theta + 245^\circ 1'.)$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	65.80	65.79	+ 0.01
1	65.33		
2	64.66		
3	63.75	63.75	.00
4	62.89		
5	62.69		
6	63.59	63.60	— .01
7	65.75		
8	68.74		
9	71.85	71.87	— .02
10	73.56		
11	76.52		
12	77.86	77.85	+ .01
13	78.79		
14	79.38		
15	79.55	79.54	+ .01
16	79.05		
17	77.81		
18	75.87	75.87	.00
19	73.53		
20	71.10		
21	69.01	68.99	+ .02
22	67.38		
23	66.38		

TABLE XVII. JULY.

$\chi = 68^\circ.75 + 7^\circ.91 \sin(\theta + 185^\circ 0') + 1^\circ.28 \sin(2\theta + 321^\circ 54') + 0^\circ.89 \sin(3\theta + 237^\circ 10'.)$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	70.57	70.57	0.00
1	70.31		
2	69.80		
3	68.96	68.97	— .01
4	68.10		
5	67.75		
6	68.46	68.47	— .01
7	70.37		
8	73.16		
9	76.22	76.22	.00
10	78.93		
11	80.95		
12	82.31	82.31	.00
13	83.15		
14	83.65		
15	83.76	83.76	.00
16	83.34		
17	81.67		
18	80.38	80.38	.00
19	78.01		
20	75.54		
21	73.34	73.35	— 0.01
22	71.79		
23	70.93		

TABLE XVIII. AUGUST.

$\chi = 74^\circ.31 + 8^\circ.34 \sin(\theta + 184^\circ 55') + 1^\circ.90 \sin(2\theta + 322^\circ 9') + 0^\circ.62 \sin(3\theta + 247^\circ 25'.)$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	69.47	69.45	+ 0.02
1	69.10		
2	68.52		
3	67.60	67.62	— .02
4	66.59		
5	66.08		
6	66.67	66.65	+ .02
7	68.55		
8	71.44		
9	74.64	74.64	.00
10	77.56		
11	77.94		
12	81.75	81.74	+ .01
13	83.08		
14	83.80		
15	83.74	83.76	— .02
16	82.75		
17	80.92		
18	78.55	78.53	+ .02
19	76.11		
20	73.88		
21	72.06	72.07	— 0.01
22	70.74		
23	69.92		

TABLE XIX. SEPTEMBER.

$$\chi = 68^\circ.26 + 8^\circ.22 \sin(\theta + 192^\circ\ 53') + 2^\circ\ 14.\sin(2\,\theta + 339^\circ\ 22') + 0^\circ.87 \sin(3\,\theta + 273^\circ\ 30'.)$$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	63.25	63.26	— 0.01
1	63.03		
2	62.63		
3	61.66	61.65	+ .01
4	60.34		
5	59.74		
6	60.61	60.61	.00
7	63.43		
8	67.31		
9	71.91	70.90	+ .01
10	73.39		
11	74.82		
12	75.87	75.87	.00
13	77.01		
14	77.89		
15	77.76	77.77	— .01
16	76.18		
17	73.36		
18	70.51	70.50	+ .01
19	68.17		
20	66.61		
21	65.51	65.50	+ 0.01
22	64.53		
23	63.72		

TABLE XX. OCTOBER.

$$\chi = 55^\circ.57 + 7^\circ.64 \sin(\theta + 187^\circ\ 40') + 2^\circ.75 \sin(2\,\theta + 326^\circ\ 27') + 0^\circ.08 \sin(3\,\theta + 327^\circ\ 44'.)$$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	51.59	51.58	+ 0.01
1	51.17		
2	50.57		
3	49.76	49.73	+ .03
4	48.85		
5	48.09		
6	48.39	48.38	+ .01
7	49.83		
8	52.35		
9	55.42	55.39	+ .03
10	58.46		
11	61.28		
12	63.57	63.59	— .02
13	65.17		
14	65.77		
15	64.98	65.01	— .03
16	63.01		
17	60.33		
18	56.61	57.62	— .01
19	55.55		
20	54.15		
21	53.24	53.27	— 0.03
22	52.62		
23	52.02		

TABLE XXI. NOVEMBER.

$$\lambda = 45^\circ.40 + 6^\circ.09 \sin(\theta + 183^\circ\ 16') + 2^\circ.41 \sin(2\,\theta + 322^\circ\ 54') + 0^\circ.51 \sin(3\,\theta + 87^\circ\ 48'.)$$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	42.38	42.37	+ 0.01
1	41.81		
2	41.32		
3	40.80	40.80	.00
4	40.30		
5	39.75		
6	39.74	39.74	.00
7	40.26		
8	42.26		
9	43.84	43.84	.00
10	46.67		
11	49.63		
12	52.16	52.16	.00
13	53.71		
14	53.98		
15	53.00	53.01	— .01
16	51.16		
17	49.01		
18	47.12	47.11	+ 0.01
19	45.70		
20	44.80		
21	44.16	44.16	0.00
22	43.59		
23	42.99		

TABLE XXII. DECEMBER.

$$\chi = 35^\circ.39 + 4^\circ.22 \sin(\theta + 179^\circ\ 38') + 1^\circ.85 \sin(2\,\theta + 312^\circ\ 26') + 0^\circ.31 \sin(3\,\theta + 73^\circ\ 19'.)$$

Hour.	Computed temp.	Observed temp.	C. — O.
	°	°	°
0	33.53	33.55	— 0.02
1	33.21		
2	32.86		
3	32.45	32.44	+ .01
4	32.02		
5	31.82		
6	31.41	31.44	— .03
7	31.59		
8	32.31		
9	33.70	33.67	+ .03
10	35.63		
11	37.76		
12	39.75	39.77	— .02
13	41.09		
14	41.54		
15	41.07	41.04	+ .03
16	39.88		
17	38.36		
18	36.87	36.87	.00
19	35.67		
20	34.85		
21	34.34	34.33	+ 0.01
22	34.03		
23	33.80		

In the computation of the quantities in the above tables, the term involving 4θ in the periodic equation (see note A,) has been employed whenever the quantity C. — O. would otherwise have been greater than the least observable difference on the thermometer scale.

From the last twelve tables we deduce the following, which shows the time and value of the diurnal maximum and minimum temperature for each month.

TABLE XXIII.

Month.	Maximum.		Minimum.	
	Time.	Temperature.	Time.	Temperature.
	h. m.	°	h. m.	°
January	13 50	38.90	6 30	28.65
February	14 45	42.30	5 45	29.94
March	14 50	48.35	5 20	35.50
April	14 55	59.50	5 0	44.91
May	14 40	72.62	4 45	54.60
June	15 10	79.60	4 30	62.43
July	14 50	83.87	4 40	67.60
August	14 45	83.84	4 55	66.02
September	14 40	78.00	4 55	59.70
October	14 10	65.80	5 15	48.04
November	13 45	54.02	5 30	39.28
December	13 50	41.60	6 15	31.40

The following table shows the most convenient hours for making three observations per day, that shall give the mean daily temperature for each month, and also indicates the proper time for making single observations for the same purpose :

TABLE XXIV.

Month.	Triple observations.			Single observations.	
	h. m.	h. m.	h. m.	h. m.	h. m.
January	7 0	11 0	18 0	10 0	21 30
February	7 0	11 0	18 30	9 50	20 25
March	7 0	12 0	20 30	9 40	20 35
April	6 0	11 0	19 0	9 0	20 40
May	6 0	12 0	20 5	8 50	20 20
June	5 0	11 0	19 0	8 40	20 5
July	5 0	11 0	20 5	8 45	20 0
August	6 0	11 0	18 50	8 50	19 50
September	6 0	12 0	18 50	8 15	18 55
October	6 0	12 0	21 0	9 5	19 0
November	7 0	11 0	18 40	9 40	19 20
December	7 0	11 0	18 0	9 50	19 20

ANNUAL VARIATION OF MEAN DAILY TEMPERATURE.

The observed mean temperature for each month, in table VIII, when corrected for unequal intervals, (see Barometer, table XXII,) becomes as follows :

	°		°
January	32.78	July	75.43
February	34.80	August	74.25
March	41.12	September	68.10
April	52.24	October	55.41
May	63.77	November	45.28
June	71.14	December	35.31

From these corrected values the constants in the following formula (see note A,) were computed.

$$\chi = 54^\circ.14 + 21^\circ.86 \sin(\theta + 234^\circ\ 36') + 0^\circ.42 \sin(2\theta + 281^\circ\ 1') + 0^\circ.48 \sin(3\theta + 9^\circ\ 4')$$
$$+ 0^\circ.39 \sin(4\theta + 214^\circ\ 2') + 0^\circ.40 \sin(5\theta + 205^\circ\ 26') + 0^\circ.28 \sin(6\theta + 90^\circ\ 0').$$

By this formula the mean temperature for each day in the year was computed and is shown in table XXV.

In this table the computed values differ from the observed values for each month by less than 0°.02.

TABLE XXV.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	32.87	33.68	37.11	46.27	58.25	67.84	73.85	75.29	72.01	61.70	49.78	39.79
2	32.81	33.75	37.32	46.64	58.64	68.07	74.01	75.26	71.80	61.24	49.48	39.44
3	32.79	33.81	37.54	47.02	59.04	68.30	74.15	75.21	71.58	60.82	49.13	39.09
4	32.76	33.88	37.77	47.37	59.40	68.55	74.30	75.15	71.35	60.36	48.83	38.77
5	32.73	33.95	38.00	47.74	59.75	68.78	74.42	75.09	71.12	59.92	48.53	38.43
6	32.70	34.04	38.23	48.12	60.12	68.98	74.54	75.02	70.89	59.48	48.22	38.10
7	32.69	34.11	38.46	48.53	60.50	69.21	74.67	74.93	70.66	59.02	47.92	37.80
8	32.68	34.17	38.71	48.92	60.87	69.41	74.78	74.89	70.38	58.61	47.60	37.47
9	32.66	34.26	38.96	49.34	61.24	69.63	74.89	74.80	70.10	58.19	47.28	37.14
10	32.68	34.37	39.22	49.72	61.58	69.85	74.97	74.73	69.81	57.77	46.96	36.84
11	32.69	34.46	39.48	50.13	61.93	70.06	75.04	74.67	69.51	57.33	46.64	36.54
12	32.70	34.55	39.72	50.53	62.26	70.26	75.12	74.58	69.20	56.91	46.32	36.27
13	32.72	34.65	40.02	50.93	62.58	70.48	75.21	74.50	68.89	56.50	46.01	35.99
14	32.77	34.77	40.30	51.34	62.92	70.70	75.28	74.40	68.56	56.11	45.69	35.73
15	32.81	34.89	40.58	51.74	63.25	70.90	75.33	74.33	68.22	55.71	45.36	35.48
16	32.84	35.02	40.87	52.17	63.57	71.10	75.37	74.24	67.85	55.30	45.04	35.23
17	32.88	35.14	41.18	52.57	63.88	71.29	75.42	74.14	67.49	54.91	44.70	34.99
18	37.93	35.27	41.47	52.98	64.18	71.51	75.45	74.04	67.12	54.53	44.35	34.77
19	32.97	35.41	41.78	53.39	64.50	71.72	75.49	73.94	66.74	54.15	44.02	34.56
20	33.01	35.55	42.08	53.77	64.73	71.90	75.50	73.85	66.34	53.80	43.68	34.34
21	33.04	35.69	42.43	54.20	65.01	72.09	75.52	73.72	65.94	53.43	43.34	34.15
22	33.09	35.84	42.77	54.61	65.30	72.28	75.53	73.59	65.56	53.09	42.98	33.98
23	33.14	36.02	43.09	55.05	65.56	72.47	75.54	73.46	65.16	52.75	42.63	33.82
24	33.19	36.18	43.39	55.44	65.84	72.67	75.55	73.32	64.73	52.42	42.27	33.69
25	33.23	36.34	43.73	55.83	66.10	72.85	75.54	73.18	64.30	52.07	41.90	33.54
26	33.28	36.52	44.07	56.24	66.34	73.03	75.53	73.04	63.87	51.73	41.56	33.42
27	33.34	36.71	44.42	56.63	66.61	73.21	75.50	72.92	63.46	51.39	41.21	33.32
28	33.39	36.91	44.77	57.03	66.86	73.40	75.48	72.75	63.01	51.06	40.83	33.20
29	33.46	. . .	45.14	57.44	67.11	73.55	75.45	72.59	62.57	50.75	40.48	33.11
30	33.53	. . .	45.51	57.87	67.37	73.70	75.43	72.39	62.14	50.42	40.14	33.03
31	33.60	. . .	45.88	. . .	67.62	. . .	75.36	72.19	. . .	50.09	. . .	32.94

From this table we find that the maximum mean daily temperature is 75°.55, and occurs on the 24th of July. The minimum is 32°.66, and occurs on the 9th of January.

The mean range is 42°.89.

The highest temperature recorded at the regular hours of observation during the five years, was 100°.5, at 15h., on the 1st of August, 1864, and the lowest, — 1° 5, occurred at 6h., on the 8th of January, 1866, giving the greatest range, = 102°.0.

From the data in table XXV, the temperature curve, (No. 2, plate II,) was plotted, showing the fluctuation of the mean daily temperature during the entire year.

RAIN.

From July 1, 1842, to December 31, 1866, inclusive, observations to ascertain the amount of rain and snow which fell in this locality, formed a part of the meteorological work at the Observatory.

Most of the observations from January 1, 1843, to January 1, 1862, appear to have been properly made, while those after January 1, 1862, were made with great care.

In the preparation of the following tables, great care was observed to reject the whole data for each year where the depth of any measurable fall of rain or snow was not recorded.

The data thus rejected comprise the occasional observations in 1849, 1850, and 1851. In several instances in these years, the officer in charge failed to make any observations for a month, but at the end of the month *estimated* the amount.

The rain-gauge was placed on the lawn, free from all shelter during driving rains, about sixty feet south of the southwest corner of the Observatory. From January 1, 1843, to June 1, 1863, the top of the receiving cylinder was about forty inches above the grass, but on June 1, 1863, it was placed sixteen inches lower, where it has since remained.

The receiving cylinder is of tin, 4.1 inches in diameter and 0.8 inch long, soldered to an inverted cone, which is loaded with lead on the outside and near the apex.

The cone rests in an aperture of a box whose top is horizontal, and this with the lead prevents disturbance during high winds.

There is an aperture at the apex of the cone through which, as it descends, the rain-water passes to a receiving bottle within, and the water thus collected was measured in a graduated glass cylinder with an internal diameter of 0.60 inch.

The apex of the cone closes the mouth of the bottle, and as the aperture in the apex is very small, there is little or no loss by evaporation when the contents are measured each day. Each inch of snow was assumed equivalent to 0.111 inch of rain, though in most cases where the snow-fall was light the equivalent was determined by melting the snow. The following table shows the amount of rain determined by the above methods in each month from 1843 to 1866, inclusive, omitting the data in 1849, 1850, and 1851 :

TABLE I.

Month.	1843.	1844.	1845.	1846.	1847.	1848.	1852.	1853.	1854.	1855.	1856.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	0.758	4.240	1.800	2.952	2.843	1.870	2.445	1.030	3.273	1.693	3.580
February	3.253	0.500	2.120	1.660	1.480	1.035	2.870	1.785	2.307	1.530	0.562
March	3.327	4.125	2.220	3.581	2.443	2.253	2.530	2.200	2.263	1.506	1.470
April	3.727	1.090	1.550	3.370	0.310	0.890	3.900	4.284	5.072	1.818	2.409
May	4.147	3.210	2.120	5.685	1.300	2.636	1.040	3.665	2.158	1.262	3.677
June	1.315	2.620	3.765	4.990	2.056	2.532	2.820	1.240	0.802	5.436	5.916
July	3.070	4.805	0.800	3.440	3.031	6.262	2.900	3.371	2.274	4.240	3.296
August	6.609	1.300	2.500	5.755	2.791	1.442	8.290	3.689	0.630	1.953	3.246
September	6.246	0.595	1.902	0.295	4.561	1.200	0.690	3.755	3.200	3.348	1.780
October	2.465	5.120	4.700	3.460	6.839	1.010	1.240	3.864	1.910	3.217	1.786
November	3.183	2.590	1.710	6.571	1.958	1.840	4.460	1.644	3.590	0.986	1.890
December	3.290	1.500	3.895	1.951	2.448	1.140	3.255	1.228	0.817	2.756	2.147

TABLE I.—Continued.

Month.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1.802	2.430	3.860	2.517	3.930	3.609	4.492	2.174	4.226	2.733
February	0.388	1.498	2.616	2.370	1.840	3.672	3.686	0.289	3.526	4.236
March	0.866	0.802	3.202	0.940	2.246	5.086	5.141	4.729	5.996	0.850
April	2.248	3.983	4.298	3.346	4.876	5.892	5.141	7.036	2.416	2.766
May	5.531	6.132	2.786	5.779	3.114	2.024	3.096	4.010	5.241	2.644
June	5.432	1.842	4.446	2.290	4.218	5.001	1.145	0.799	4.858	4.072
July	3.254	3.674	1.398	2.526	5.050	5.849	7.181	1.354	5.456	6.704
August	8.053	2.404	2.646	4.730	7.496	2.539	1.270	3.374	0.963	1.946
September	2.127	2.578	5.980	4.312	2.358	1.770	2.580	2.450	2.866	6.484
October	2.354	2.502	2.184	5.166	3.511	3.005	4.006	1.284	2.139	10.132
November	1.382	3.480	1.524	3.916	4.690	2.289	2.194	3.216	2.260	1.560
December	5.838	5.240	2.938	2.396	1.000	0.980	3.630	3.308	4.722	2.735

From the data in table I, we derive the annual amount of rain for twenty-one years, as shown in table II, and the mean *monthly* amount from the observations during twenty-one years, as exhibited in table III :

TABLE II.

Year.	Amount.	Year.	Amount.	Year.	Amount.
	in.		in.		in.
1843	40.892	1853	31.755	1860	40.288
1844	31.695	1854	28.296	1861	44.329
1845	29.082	1855	29.745	1862	41.716
1846	43.710	1856	31.759	1863	43.562
1847	32.060	1857	39.295	1864	34.014
1848	24.110	1858	36.565	1865	44.669
1852	36.440	1859	37.878	1866	46.862
		Mean	36.606 inches.		

TABLE III.

Month.	Mean amount.	Month.	Mean amount.
	in.		in.
January	2.774	July	3.806
February	2.011	August	3.506
March	2.775	September	2.957
April	3.353	October	3.424
May	3.346	November	2.711
June	3.219	December	2.724

From table III, we find that the maximum mean monthly fall of rain occurs in July, and the minimum in February, and that nearly as much falls in April, May, June, July, and August, as in the remaining seven months of the year.

The greatest number of rains occur in spring, while the greatest amount of rain in a single storm usually occurs about the middle of autumn.

The greatest amount of rain in any month fell in October, 1866. There were 10.132 inches, of which 7.92 inches fell in fifty-six hours.

It has long been a popular theory that on or about the time of the vernal and autumnal equinoxes, a very severe rain-storm is almost certain to occur, but from the carefully compiled data in the following table, it appears that such a theory is entitled to little credit in this locality.

Believing that a period of fourteen days—from the 15th to the 28th, inclusive, of March and September—is sufficiently comprehensive to embrace all phenomena that can properly be termed "Equinoctial Rain Storms," it has been assumed as the equinoctial period.

In table IV is shown the annual amount of rain, the amount in March, in the vernal equinoctial period, in September, and in the autumnal equinoctial period, together with the mean amount for each date :

TABLE IV.

Year.	Annual amount.	March.	Vernal equinox.	September.	Autum'l equinox.
	in.	in.	in.	in.	in.
1843	40.892	3.827	2.547	6.246	1.656
1844	31.695	4.125	1.950	0.595	0.575
1845	29.082	2.220	0.000	1.902	0.544
1846	43.710	3.581	1.310	0.295	0.035
1847	32.060	2.443	1.202	4.561	3.254
1848	24.110	2.253	0.542	1.200	0.590
1852	36.440	2.530	1.870	0.690	0.000
1853	31.755	2.200	0.800	3.755	0.115
1854	28.296	2.263	0.730	3.200	1.460
1855	29.745	1.506	0.868	3.348	0.696
1856	31.759	1.470	0.620	1.780	0.960
1857	39.295	0.866	0.376	2.147	1.961
1858	36.565	0.802	0.080	2.578	0.962
1859	37.878	3.202	0.654	5.980	5.580
1860	40.288	0.940	0.600	4.312	3.296
1861	44.329	2.246	0.982	2.358	0.952
1862	41.716	5.086	3.502	1.770	0.130
1863	43.562	5.141	2.690	2.580	1.960
1864	34.014	4.729	0.990	2.450	0.000
1865	44.669	5.996	1.380	2.866	0.000
1866	46.862	0.850	0.710	6.484	2.770
Mean	36.606	2.775	1.162	2.909	1.309

The mean fall of rain for each fourteen-day period in a year is 1.403 inch, for each fourteen-day period in March it is 1.253 inch, and for each fourteen-day period in September it is 1.357 inch.

For each fourteen-day period, except the equinoctial period, in March it is 1.328 inch, and in September it is 1.400 inch.

Hence, we find that the mean fall of rain in the *vernal* equinoctial period is 0.241 inch *less* than the mean fall in each fourteen-day period in the year, 0.091 inch *less* than for each fourteen-day period in March, and 0.166 inch *less* than for the remaining fourteen-day period in March.

The mean fall of rain in the *autumnal* equinoctial period is 0.094 inch *less* than the mean fall in each fourteen-day period in the year, 0.048 inch *less* than for each fourteen-day period in September, and 0.091 inch *less* than for the remaining fourteen-day periods in September.

The average mean fall of rain for the fourteen-day periods in March is 0.150 inch *less* than for similar periods in the entire year, and in September it is 0.046 inch *less.*

The inevitable conclusion, therefore, is that the amount of rain in March and September is *less* than the mean monthly fall for the year, and the fall during the equinoctial period is *less* than the mean fall during periods of equal duration througout the year.

WIND.

The direction and force of the wind have been determined entirely by estimation.

A small vane revolving freely on the top of the time-ball staff, about fifty-five feet from the ground, was used in wind observations, and the known azimuths of the principal lines of the building served as guides in determining the direction.

No attempt was made to observe angles of deviation less than 22°.5, and all the observations were grouped under the following heads: North, Northeast, East, Southeast, South, Southwest, West, and Northwest. As these azimuthal angles are large (45° 0′,) the following tables are doubtless as reliable as can be obtained without the aid of some recording apparatus.

Table I shows the number of times the wind blew from the N., NE., E., SE., S., SW., W., and NW., at the hours of observations in each month:

TABLE I.

Year.	JANUARY.								FEBRUARY.								MARCH.							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
1862 . . .	16	78	9	18	12	13	12	80	17	46	8	27	21	12	10	67	13	60	8	18	13	13	38	75
1863 . . .	28	41	13	18	53	13	16	70	41	27	15	22	30	14	37	35	29	43	29	16	19	19	40	55
1864 . . .	15	46	20	32	29	16	35	62	13	11	12	27	58	17	30	62	46	30	13	10	31	9	21	87
1865 . . .	13	30	15	10	33	9	24	114	30	31	4	17	24	3	30	84	8	22	25	27	56	30	25	52
1866 . . .	18	25	13	19	24	17	23	111	9	9	7	14	41	15	24	93	18	13	8	7	59	15	23	100

Year.	APRIL.								MAY.								JUNE.							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
1862 . . .	16	46	19	45	24	16	24	32	21	48	9	39	26	16	24	52	21	24	9	26	37	43	21	62
1863 . . .	28	26	15	21	38	10	36	66	23	34	13	31	57	19	38	35	15	19	16	38	42	27	38	48
1864 . . .	27	22	14	20	32	13	37	68	21	17	23	25	37	35	34	43	42	21	30	13	30	24	30	52
1865 . . .	8	26	31	12	62	15	31	54	29	24	7	28	58	27	19	57	15	28	15	31	65	31	36	20
1866 . . .	19	37	13	21	48	18	19	48	19	4	5	14	67	27	27	81	14	9	24	21	75	28	23	36

TABLE I—Continued.

Year.	JULY.								AUGUST.								SEPTEMBER.							
	N	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
1862 . . .	27	39	8	16	45	34	29	48	33	31	8	31	39	33	15	56	26	40	8	37	30	10	23	59
1863 . . .	25	27	16	44	66	14	12	39	31	12	3	18	73	30	38	28	17	22	22	32	38	16	30	57
1864 . . .	33	29	19	24	30	39	28	43	29	28	17	11	41	27	39	56	22	13	11	22	60	21	24	64
1865 . . .	35	14	11	9	34	36	43	64	31	21	17	14	37	32	22	57	44	26	17	13	36	31	31	43
1866 . . .	14	21	5	28	62	23	32	51	24	3	7	25	40	25	32	83	19	34	10	28	56	19	23	48

Year.	OCTOBER.								NOVEMBER.								DECEMBER.							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
1862 . . .	26	40	10	25	44	18	24	58	15	25	2	21	33	28	34	88	9	10	4	26	52	27	43	82
1863 . . .	38	15	30	31	20	8	39	65	24	14	2	17	61	17	47	59	26	31	16	22	31	22	22	67
1864 . . .	24	17	16	8	30	8	66	80	22	13	10	28	58	16	26	67	24	28	15	12	37	14	27	88
1865 . . .	22	20	8	15	19	15	47	102	34	21	8	8	37	10	29	93	25	24	22	24	29	26	8	94
1866 . . .	26	37	18	31	32	14	26	63	21	10	7	20	54	15	27	86	21	16	12	7	30	19	39	104

The following table exhibits the aggregate of the results in table I:

TABLE II.

Month.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
January	90	220	70	97	151	68	110	437
February	110	124	56	107	174	61	131	341
March	114	168	83	78	178	86	147	369
April	98	157	92	119	204	72	147	268
May	113	127	57	137	245	124	142	268
June	107	101	94	129	249	153	148	218
July	134	130	59	121	237	146	144	245
August	148	95	54	99	230	147	146	280
September	128	135	68	132	220	97	131	271
October	136	129	82	110	145	63	202	368
November	116	83	29	94	243	86	163	393
December	105	109	69	91	179	108	139	435
Total	1399	1578	813	1314	2455	1211	1750	3893

Omitting the data for winds due East and West, which seem to change very little from month to month, and treating the remainder in two groups as North and South winds, we have the ratio of the prevalence of North and South currents of air for each month in the year, as shown in—

TABLE III.

Month.	North.	South.	$\frac{N.}{S.}$
January	747	316	2.4
February	575	342	1.7
March	651	342	1.9
April	523	395	1.3
May	508	506	1.0
June	426	531	0.8
July	509	504	1.0
August	523	476	1.1
September	534	449	1.2
October	633	318	2.0
November	592	423	1.4
December	649	378	1.7

By reference to the article on Barometric Pressure, it will be seen that a "high barometer" and a northerly wind are usually coincident, as also a "low barometer" and a southerly wind.

The observations of *force of wind* are simply estimates, and since at best they are but "rough guesses," and of no real scientific value, they need receive no further attention.

NOTE A.

In the discussion of observations of meteorological phenomena, it is necessary to determine for each element its *mean amount* in proper units, and the *extent* and *laws* of its deviation from that amount.

These results are the most readily obtained from formulæ, deduced from the discussion of the principles of the universal dynamical law, "All periodicity in the action of a cause propagates itself into every, even the remotest, effect of that cause, through whatever chain of intermediate arrangements the action is carried out."

When the effect is the result of the same law of periodicity, operating from the same cause through several systems of intermediate connection, its numerical value, in the simplest case of direct action, depends upon the calculation of an expression of the form

$$a+b\sin(n\,x+c)$$

in which a represents the mean value of the result, b and c constant quantities, and $n\,x$ an arc directly proportional to the time and inversely proportional to the period, while the more general expression becomes a series of similar terms, involving not only $n\,x$ but its multiples $2\,n\,x$, $3\,n\,x$, *&c.*, with their respective constants, which run through their periods in one half, one third, &c., of the period in which they originated; and the effect is represented by

$$e=a+b'\sin(x+c')+b''\sin(2\,x+c'')+b'''\sin 3\,x+c''')+\&c. \quad (1.)$$

Now, in order to learn the extent and the law of fluctuation, it is necessary to determine the constants which enter into the periodical terms for each series of observations treated.

To do this properly from a considerable number of observations, requires the use of the "Method of Least Squares."

When the observations are numerous, and made at irregular epochs, the labor of calculation becomes immense, but when a full series of observations are made at regular periods—dividing the cycle into any number of equal intervals—the application of the following simple formulæ, originally investigated by Bessel, will give the most probable values of the constants.

The entire cycle will be represented by 360°. Let θ represent the interval, in arc, between any two of the equidistant observations, and its multiples 2θ, 3θ, 4θ, ... $n\theta$, will represent the interval between the 1st and 3d, 1st and 4th, 1st and 5th, ... and 1st and nth observations. Let v_1, v_2, v_3, ... v_n, represent the observed values at equidistant epochs throughout the period.

Convert θ, 2θ, 3θ, ... $n\theta$ into degrees at the rate of 15° per hour for the diurnal, and 30° per month for the annual fluctuation, and represent their sines by s_1, s_2, s_3, ... s_n, and their cosines by c_1, c_2, c_3, ... c_n.

With these quantities compute a, a_1, a_2, a_3, *&c.*, b_1, b_2, b_3, *&c.*, from the following formulæ in which N equals the number of observations in a cycle.

$$\left.\begin{aligned}
a &= \frac{1}{N}(v_1+v_2+ \ldots\ldots\ldots\ldots +v_n)\\
a_1 &= \frac{2}{N}(c_1\cdot v_1+c_2\cdot v_2+ \ldots\ldots\ldots +c_n\cdot v_n)\\
a_2 &= \frac{2}{N}(c_2\cdot v_1+c_4\,v_2+ \ldots\ldots\ldots +c_{2n}\cdot v_n)\\
a_3 &= \frac{2}{N}(c_3\cdot v_1+c_6\cdot v_2+ \ldots\ldots\ldots +c_{3n}\cdot v_n)\\
b_1 &= \frac{2}{N}(s_1\cdot v_1+s_2\cdot v_2+ \ldots\ldots\ldots +s_n\cdot v_n)\\
b_2 &= \frac{2}{N}(s_2\cdot v_1+s_4\cdot v_2+ \ldots\ldots\ldots +s_{2n}\cdot v_n)\\
b_3 &= \frac{2}{N}(s_3\cdot v_1+s_6\cdot v_2+ \ldots\ldots\ldots +s_{3n}\cdot v_n)
\end{aligned}\right\}(2)$$

These will be the most probable values of the coefficients in the general expression for the effect in the periodical form:

$$e=a+a_1 \cos\theta+b_1 \sin\theta+a_2 \cos 2\theta+b_2 \sin 2\theta+.\ \&c.$$

which by taking $a=a$, $\beta_1=\sqrt{a_1^2+b_1^2}$ and $\tan\gamma_1=\frac{a_1}{b_1}$

may be transformed into

$$\chi=a+\beta_1 \sin(\theta+\gamma_1)+\beta_2 \sin(2\theta+\gamma_2)+\beta_3 \sin(3\theta+\gamma_3)+\beta_4 \sin(4\theta+\gamma_4)+\ \&c.,$$

the general formula for periodic variation in which $\chi=$ the result at any epoch designated by θ, $a=$ the mean amount of the observed phenomena in appropriate units, β_1, β_2, β_3, &c., the parameters of the fluctuation of the force in the principal and subordinate periods—the period involving 2θ being one half the first, and that involving 3θ one third the first, &c.

θ represents an arc proportional directly to the time and inversely to the period represented by 360°. γ_1, γ_2, γ_3, &c., represent angular constants determining the epochs of fluctuation, their value depending on the signs of a_1, b_1, a_2, b_2, &c., considered as the sines and cosines respectively of the several angles.

From equations (2) the values of a, a_1, a_2, a_3, &c., b_1, b_2, b_3, &c., β_1, β_2, β_3, &c., and γ_1, γ_2, γ_3, &c., are found, for twenty-four equidistant observations in a cycle, to be as follows:

$$a=\tfrac{1}{24}(v_1+v_2+v_3+v_4+v_5+v_6+v_7+v_8+v_9+v_{10}+v_{11}+v_{12}+v_{13}+v_{14}+v_{15}+v_{16}+v_{17}+v_{18}+v_{19}+v_{20}+v_{21}+v_{22}+v_{23}+{}_{24}).$$

$$12\,a_1=0.966[(v_1+v_{23})-(v_{11}+v_{13})]+0.866[(v_2+v_{22})-(v_{10}+v_{14})]+0.707[(v_3+v_{21})-(v_9+v_{15})]+0.500[(v_4+v_{20})-(v_8+v_{16})]$$
$$+0.259[(v_5+v_{19})-(v_7+v_{17})]-v_{12}+v_{24}.$$

$$12\,b_1=0.259[(v_1+v_{11})-(v_{13}+v_{23})]+0.500[(v_2+v_{10})-(v_{14}+v_{22})]+0.707[(v_3+v_9)-(v_{15}+v_{21})]+0.866[(v_4+v_8)-(v_{16}+v_{20})]$$
$$+0.966[(v_5+v_7)-(v_{17}+v_{19})+v_6-v_{18}.$$

$$\beta_1=\sqrt{a_1^2+b_1^2} \qquad \tan\gamma_1=\frac{a_1}{b_1}$$

$$12\,a_2=0.866[(v_1+v_{11}+v_{13}+v_{23})-(v_5+v_7+v_{17}+v_{19})]+.0.500[(v_2+v_{10}+v_{14}+v_{22})-(v_4+v_8+v_{16}+v_{20})]+(v_{12}+v_{24})-(v_6+v_{18}).$$

$$12\,b_2=0.500[(v_1+v_5+v_{13}+v_{17})-(v_7+{}_{11}+v_{19}+v_{23})]+0.866[(v_2+v_4+v_{14}+v_{16})-(v_8+v_{10}+v_{20}+v_{22})]+(v_3+v_{15})-(v_9+v_{21}).$$

$$\beta_2=\sqrt{a_2^2+b_2^2} \qquad \tan\gamma_2=\frac{a_2}{b_2}$$

$$12\,a_3=0.707[(v_1+v_7+v_9+v_{15}+v_{17}+v_{22})-(v_3+v_5+v_{11}+v_{13}+v_{19}+v_{21})]+(v_8+v_{16}+v_{24})-(v_4+v_{12}+v_{20}).$$

$$12\,b_3=0.707[(v_1+v_3+v_9+v_{11}+v_{17}+v_{19})-(v_5+v_7+v_{13}+v_{15}+v_{21}+v_{23})]+(v_2+v_{10}+v_{18})-(v_6+v_{14}+v_{22}).$$

$$\beta_3=\sqrt{a_3^2+b_3^2} \qquad \tan\gamma_3=\frac{a_3}{b_3}$$

$$12\,a_4=0.500[(v_1+v_5+v_7+v_{11}+v_{13}+v_{17}+v_{19}+v_{23})-(v_2+v_4+v_8+v_{10}+v_{14}+v_{16}+v_{20}+v_{22})]+(v_6+v_{12}+v_{18}+v_{24})-(v_3+v_9+v_{15}+v_{21}).$$

$$12\,b_4=0.866[(v_1+v_2+v_7+v_8+v_{13}+v_{14}+v_{19}+v_{20})-(v_4+v_5+v_{10}+v_{11}+v_{16}+v_{17}+v_{22}+v_{23})].$$

$$\beta_4=\sqrt{a_4^2+b_4^2} \qquad \tan\gamma_4=\frac{a_4}{b_4}$$

$$12\,a_5=0.259[(v_1+v_{23})-(v_{11}+v_{13})]+0.500[(v_4+v_{20})-(v_8+v_{16})]+0.707[(v_9+v_{15})-(v_3+v_{21})]+0.866[(v_{10}+v_{14})-(v_2+v_{22})]$$
$$+0.966[(v_5+v_{19})-(v_7+v_{17})]+v_{24}-v_{12}.$$

$$12\,b_5=0.966[(v_1+v_{11})-(v_{13}+v_{23})]+0.866[(v_{16}+v_{20})-(v_4+v_8)]+0.707[(v_{15}+v_{21})-(v_3+v_9)]+0.500[(v_2+v_{10})-(v_{14}+v_{22})]$$
$$+0.259[(v_5+v_7)-(v_{17}+v_{19})]+v_6-v_{18}.$$

$$\beta_5=\sqrt{a_5^2+b_5^2} \qquad \tan\gamma_5=\frac{a_5}{b_5}$$

$$12\,a_6=(v_4+v_8+v_{12}+v_{16}+v_{20}+v_{24})-(v_2+v_6+v_{10}+v_{14}+v_{18}+v_{22}).$$

$$12\,b_6=(v_1+v_5+v_9+v_{13}+v_{17}+v_{21})-(v_3+v_7+v_{11}+v_{15}+v_{19}+v_{23}).$$

$$\beta_6=\sqrt{a_6^2+b_6^2} \qquad \tan\gamma_6=\frac{a_6}{b_6}$$

$$12\,a_7=0.259[(v_{11}+v_{13})-(v_1+v_{23})]+0.500[(v_4+v_{20})-(v_8+v_{16})]+0.707[(v_3+v_{21})-(v_9+v_{15})]+0.866[(v_{10}+v_{14})-(v_2+v_{22})]$$
$$+0.966[(v_7+v_{17})-(v_5+v_{19})]+v_{24}-v_{12}.$$

$$12\,b_7=0.966[(v_1+v_{11})-(v_{13}+v_{23})]+0.866[(v_4+v_8)-(v_{16}+v_{20})]+0.707[(v_{15}+v_{21})-(v_3+v_9)]+0.500[(v_{14}+v_{22})-(v_2+v_{10})]$$
$$+0.259[(v_5+v_7)-(v_{17}+v_{19})]+v_{18}-v_6.$$

$$\beta_7=\sqrt{a_7^2+b_7^2} \qquad \tan\gamma_7=\frac{a_7}{b_7}$$

$$12\,a_8=-0.500\,(v_1+v_2+v_4+v_5+v_7+v_8+v_{10}+v_{11}+v_{13}+v_{14}+v_{16}+v_{17}+v_{19}+v_{20}+v_{22}+v_{23})+(v_3+v_6+v_9+v_{12}+v_{15}+v_{18}+v_{21}+v_{24}).$$

$$12\,b_8=0.866[(v_1+v_4+v_7+v_{10}+v_{13}+v_{16}+v_{19}+v_{22})-(v_2+v_5+v_8+v_{11}+v_{14}+v_{17}+v_{20}+v_{23})].$$

$$\beta_8=\sqrt{a_8^2+b_8^2} \qquad \tan\gamma_8=\frac{a_8}{b_8}$$

$$12\,a_9=0.707\,[(v_3+v_5+v_{11}+v_{13}+v_{19}+v_{21})-(v_1+v_7+v_9+v_{15}+v_{17}+v_{23})]+(v_8+v_{16}+v_{24})-(v_4+v_{12}+v_{20}).$$

$$12\,b_9=0.707\,[(v_1+v_3+v_9+v_{11}+v_{17}+v_{19})-(v_5+v_7+v_{13}+v_{15}+v_{21}+v_{23})]+(v_6+v_{14}+v_{22})-(v_2+v_{10}+v_{18}).$$

$$\beta_9=\sqrt{a_9^2+b_9^2} \qquad \tan\gamma_9=\frac{a_9}{b_9}$$

$$12\,a_{10}=0.866[(v_5+v_7+v_{17}+v_{19})-(v_1+v_{11}+v_{13}+v_{23})]+0.500\,[(v_2+v_{10}+v_{14}+v_{22})-(v_4+v_8+v_{16}+v_{20})]+(v_{12}+v_{24})-(v_6+v_{18}).$$

$$12\,b_{10}=0.500[(v_1-v_5+v_{13}+v_{17})-(v_7+v_{11}+v_{19}+v_{23})]+0.866\,[(v_8+v_{10}+v_{20}+v_{22})-(v_2+v_4+v_{14}+v_{16})]+(v_3+v_{15})-(v_9+v_{21}).$$

$$\beta_{10}=\sqrt{a_{10}^2+b_{10}^2} \qquad \tan\gamma_{10}=\frac{a_{10}}{b_{10}}$$

$$\begin{aligned}12\,a_{11}=&\,0.966\,[(v_{11}+v_{13})-(v_1+v_{23})]+0.866\,[(v_2+v_{22})-(v_{10}+v_{14})]+0.707\,[(v_9+v_{15})-(v_3+v_{21})]+0.500\,[(v_4+v_{20})-(v_8+v_{16})]\\&+0.259\,[(v_7+v_{17})-(v_5+v_{19})]+v_{24}-v_{12}.\end{aligned}$$

$$\begin{aligned}12\,b_{11}=&\,0.259\,[(v_1+v_{11})-(v_{13}+v_{23})]+0.500\,[(v_{14}+v_{22})-(v_2+v_{10})]+0.707\,[(v_3+v_9)-(v_{15}+v_{21})]+0.866\,[(v_{16}+v_{20})-(v_4+v_8)]\\&+0.966\,[(v_5+v_7)-(v_{17}+v_{19})]+v_{18}-v_6.\end{aligned}$$

$$\beta_{11}=\sqrt{a_{11}^2+b_{11}^2} \qquad \tan\gamma_{11}=\frac{a_{11}}{b_{11}}$$

$$24\,a_{12}=(v_2+v_4+v_6+v_8+v_{10}+v_{12}+v_{14}+v_{16}+v_{18}+v_{20}+v_{22}+v_{24})-(v_1+v_3+v_5+v_7+v_9+v_{11}+v_{13}+v_{15}+v_{17}+v_{19}+v_{21}+v_{23}).$$

$$24\,b_{12}=0$$

$$\beta_{12}=a_{12} \qquad \gamma_{12}=90^\circ$$

The computation of results by the above formulæ is very tedious; and in most cases it is preferable to treat the observations at the odd and even hours separately as if they were distinct series of observations, twelve in a cycle. In this way we also have a good check on the computation of the final result.

The formulæ for computing the constants from *twelve* equidistant observations are as follows:

$$a=\tfrac{1}{12}(v_1+v_2+v_3+v_4+v_5+v_6+v_7+v_8+v_9+v_{10}+v_{11}+v_{12}).$$

$$6\,a_1=0.866\,[(v_1+v_{11})-(v_5+v_7)]+0.500[(v_2+v_{10})-(v_4+v_8)]+v_{12}-v_6.$$

$$6\,b_1=0.500\,[(v_1+v_5)-(v_7+v_{11})]+0.866\,[(v_2+v_4)-(v_8+v_{10})]+v_3-v_9.$$

$$\beta_1=\sqrt{a_1^2+b_1^2} \qquad \tan\gamma_1=\frac{a_1}{b_1}$$

$$6\,a_2=0.500\,[(v_1+v_5+v_7+v_{11})-(v_2+v_4+v_8+v_{10})]+(v_6+v_{12})-(v_3+v_9).$$

$$6\,b_2=0.866\,[(v_1+v_2+v_7+v_8)-(v_4+v_5+v_{10}+v_{11})].$$

$$\beta_2=\sqrt{a_2^2+b_2^2} \qquad \tan\gamma_2=\frac{a_2}{b_2}$$

$$6\,a_3=(v_4+v_8+v_{12})-(v_2+v_6+v_{10}).$$

$$6\,b_3=(v_1+v_5+v_9)-(v_3+v_7+v_{11}).$$

$$\beta_3=\sqrt{a_3^2+b_3^2} \qquad \tan\gamma_3=\frac{a_3}{b_3}$$

$$6\,a_4=-0.500\,(v_1+v_2+v_4+v_5+v_7+v_8+v_{10}+v_{11})+(v_3+v_6+v_9+v_{12}).$$

$$6\,b_4=0.866\,[(v+v_{14}+v_7+v_{10})-(v_2+v_5+v_8+v_{11})].$$

$$\beta_4=\sqrt{a_4^2+b_4^2} \qquad \tan\gamma_4=\frac{a_4}{b_4}$$

$$6\,a_5=0.866\,[(v_5+v_7)-(v_1+v_{11})]+0.500\,[(v_2+v_{10})-(v_4+v_8)]+v_{12}-v_6.$$

$$6\,b_5=0.500\,[(v_1+v_5)-(v_7+v_{11})]+0.866\,[(v_8+v_{10})-(v_2+v_4)]+v_3-v_9.$$

$$\beta_5=\sqrt{a_5^2+b_5^2} \qquad \tan\gamma_5=\frac{a_5}{b_5}$$

$$12\,a_6=(v_2+v_4+v_6+v_8+v_{10}+v_{12})-(v_1+v_3+v_5+v_7+v_9+v_{11}).$$

$$12\,b_6=0$$

$$\beta_6=a_6 \qquad \gamma_6=90^\circ$$

For *eight* equidistant observations in a cycle we have—

$$a=\tfrac{1}{8}(v_1+v_2+v_3+v_4+v_5+v_6+v_7+v_8).$$

$$4\,a_1=0.707\,[(v_1+v_7)-(v_3+v_5)]+v_8-v_4.$$

$$4\,b_1=0.707\,[(v_1+v_3)-(v_5+v_7)]+v_2-v_6.$$

$$\beta_1=\sqrt{a_1^2+b_1^2} \qquad \tan\gamma_1=\frac{a_1}{b_1}$$

$$4\,a_2=(v_4+v_8)-(v_2+v_6).$$

$$4\,b_2=(v_1+v_5)-(v_3+v_7).$$

$$\beta_2=\sqrt{a_2^2+b_2^2} \qquad \tan\gamma_2=\frac{a_2}{b_2}$$

$$4\,a_3=0.707\,[(v_3+v_5)-(v_1+v_7)]+v_8-v_4.$$

$$4\,b_3=0.707\,[(v_1+v_3)-(v_5+v_7)]+v_6-v_2.$$

$$\beta_3=\sqrt{a_3^2+b_3^2} \qquad \tan\gamma_3=\frac{a_3}{b_3}.$$

$$8\,a_4=(v_2+v_4+v_6+v_8)-(v_1+v_3+v_5+v_7).$$

$$8\,b_4=0$$

$$\beta_4=a_4 \qquad \gamma_4=90^\circ$$

For *six* equidistant observations in a cycle we have—

$$a=\tfrac{1}{6}(v_1+v_2+v_3+v_4+v_5+v_6).$$

$$3\,a_1=0.500\,[(v_1+v_5)-(v_2+v_4)]+v_6-v_3.$$

$$3\,b_1=0.866\,[(v_1+v_2)-(v_4+v_5)].$$

$$\beta_1=\sqrt{a_1^2+b_1^2} \qquad \tan\gamma_1=\frac{a_1}{b_1}$$

$$3\,a_2=-0.500\,(v_1+v_2+v_4+v_5)+v_3+v_6.$$

$$3\,b_2=0.866[(v_1+v_4)-(v_2+v_5)].$$

$$\beta_2=\sqrt{a_2^2+b_2^2} \qquad \tan\gamma_2=\frac{a_2}{b_2}$$

$$6\,a_3=(v_2+v_4+v_6)-(v_1+v_3+v_5).$$

$$6\,b_3=0$$

$$\beta_3=a_3 \qquad \gamma_3=90^\circ$$

In many cases it is not necessary to use all the terms in the preceding formulæ, three fourths of the whole number of terms being usually sufficient to obtain a result differing from the true value by no more than the probable error of ordinary observations.

[The following article on Clouds was omitted from its proper place (before Note A) by mistake.]

CLOUDS.

The observations of clouds previous to 1862 were as unreliable as were the data for pressure and temperature for the same period, and, consequently, have been rejected.

From 1862 to 1866, inclusive, the observations were made at midnight, 3h., 6h., 9h., 12h., 15h., 18h., and 21h., by experienced observers, and the observations were carefully examined each day by the officer in charge of the meteorological department, before the circumstances attending the observation were forgotten by the observer. In the description of the prevailing forms of clouds the nomenclature of Howard was used; C., K., S., N., being symbols for the forms which he designates as *cirrus*, *cumulus*, *stratus*, and *nimbus*, and the double letters C. S., C. K., &c., their combinations to indicate *cirro-stratus*, *cirro-cumulus*, &c. These letters have been employed for the same purpose in the following tables. The portion of the sky obscured was simply an estimate from careful scrutiny of the whole hemisphere. A clear sky was denoted by 0, and total obscuration by 10. Light haze, insufficient to perceptibly modify the light of the sun, was not reckoned as cloudiness.

In the tables representing *mean cloudiness* total obscuration has been represented, for the sake of convenience, by 1.0 and the mean cloudiness given in hundredths. The following table exhibits the mean cloudiness in each month from 1862 to 1866, inclusive:

TABLE I.

Month.	1862.	1863.	1864.	1865.	1866.
January	0.78	0.65	0.51	0.58	0.67
February	.72	.65	.47	.57	.42
March	.63	.70	.57	.52	.45
April	.62	.64	.69	.55	.51
May	.55	.43	.50	.56	.44
June	.56	.59	.32	.56	.42
July	.50	.64	.43	.53	.41
August	.38	.35	.47	.46	.50
September	.38	.39	.58	.47	.59
October	.43	.50	.47	.34	.44
November	.53	.45	.64	.47	.49
December	.42	.52	.70	.66	.61
Mean	.54	.54	.53	.52	.50

The mean cloudiness for the entire period of five years therefore is 0.526, and the mean for each year is remarkably near the mean for the period.

Table II exhibits the mean cloudiness of each month during the time included in the observations.

TABLE II.

January	0.64	May	0.50	September	0.48
February	.57	June	.49	October	.44
March	.57	July	.50	November	.52
April	.60	August	.43	December	.58

The following tables show the character of the clouds that prevailed at the hours of observation in each month during the five years, the figures in the table indicating the number of times each form was observed in a month:

TABLE III. 1862.

Month.	C.	C. K.	C. S.	K.	K. S.	S.	N.
January	6	40	19	78	1	11	57
February	16	66	13	57	1	10	36
March	14	81	16	47	1	13	43
April	19	39	21	47	2	13	46
May	34	71	15	37	8	4	27
June	30	96	13	34	6	7	20
July	39	91	18	41	6	10	18
August	27	113	23	10	15	10	10
September	21	61	14	39	7	18	12
October	17	51	19	36	6	29	22
November	6	66	27	44	13	16	32
December	27	56	30	38	3	17	10

TABLE IV. 1863.

Month.	C.	C. K.	C. S.	K.	K. S.	S.	N.
January	19	55	22	45	7	19	43
February	14	54	24	39	4	8	52
March	16	63	22	54	2	19	49
April	22	63	11	43	1	11	47
May	35	60	10	36	0	6	20
June	36	92	10	47	6	3	14
July	23	83	5	52	4	5	31
August	52	82	18	11	9	9	6
September	17	68	15	30	9	7	6
October	27	58	30	30	11	11	25
November	23	53	22	31	15	32	14
December	20	40	36	41	12	22	32

TABLE V. 1864.

Month.	C.	C. K.	C. S.	K.	K. S.	S.	N.
January	26	40	30	35	0	11	29
February	21	57	17	43	0	19	9
March	23	42	17	51	6	10	45
April	24	72	14	31	12	5	45
May	41	89	2	35	1	3	20
June	55	94	10	11	0	3	5
July	45	101	9	12	2	3	6
August	34	104	13	42	2	8	13
September	31	81	11	43	4	3	21
October	30	69	23	32	3	10	16
November	16	60	15	45	6	12	45
December	15	52	20	67	12	9	24

TABLE VI. 1865.

Month.	C.	C. K.	C. S.	K.	K. S.	S.	N.
January	25	63	22	42	2	13	33
February	22	67	17	23	1	6	30
March	34	67	18	39	2	7	38
April	30	60	6	41	1	2	18
May	25	83	8	41	0	5	32
June	31	93	7	41	0	5	15
July	28	109	11	37	4	7	16
August	28	106	10	36	1	8	8
September	17	99	12	34	2	4	3
October	29	72	19	27	4	12	18
November	14	47	20	43	5	12	21
December	3	54	19	61	1	5	42

TABLE VII. 1866.

Month.	C.	C. K.	C. S.	K.	K. S.	S.	N.
January	6	61	11	84	4	0	31
February	19	38	8	38	3	5	29
March	25	64	18	51	7	17	12
April	41	65	8	55	3	6	28
May	51	58	4	36	0	3	25
June	33	105	12	23	2	14	16
July	42	118	16	11	4	4	10
August	29	101	12	32	1	0	18
September	28	95	12	34	3	2	32
October	18	77	14	20	3	4	28
November	15	73	30	35	16	6	16
December	23	63	14	44	14	13	29

From tables III to VII, inclusive, we find the aggregate distribution of clouds in each year, and the mean distribution for the period of five years as shown in the following table.

TABLE VIII.

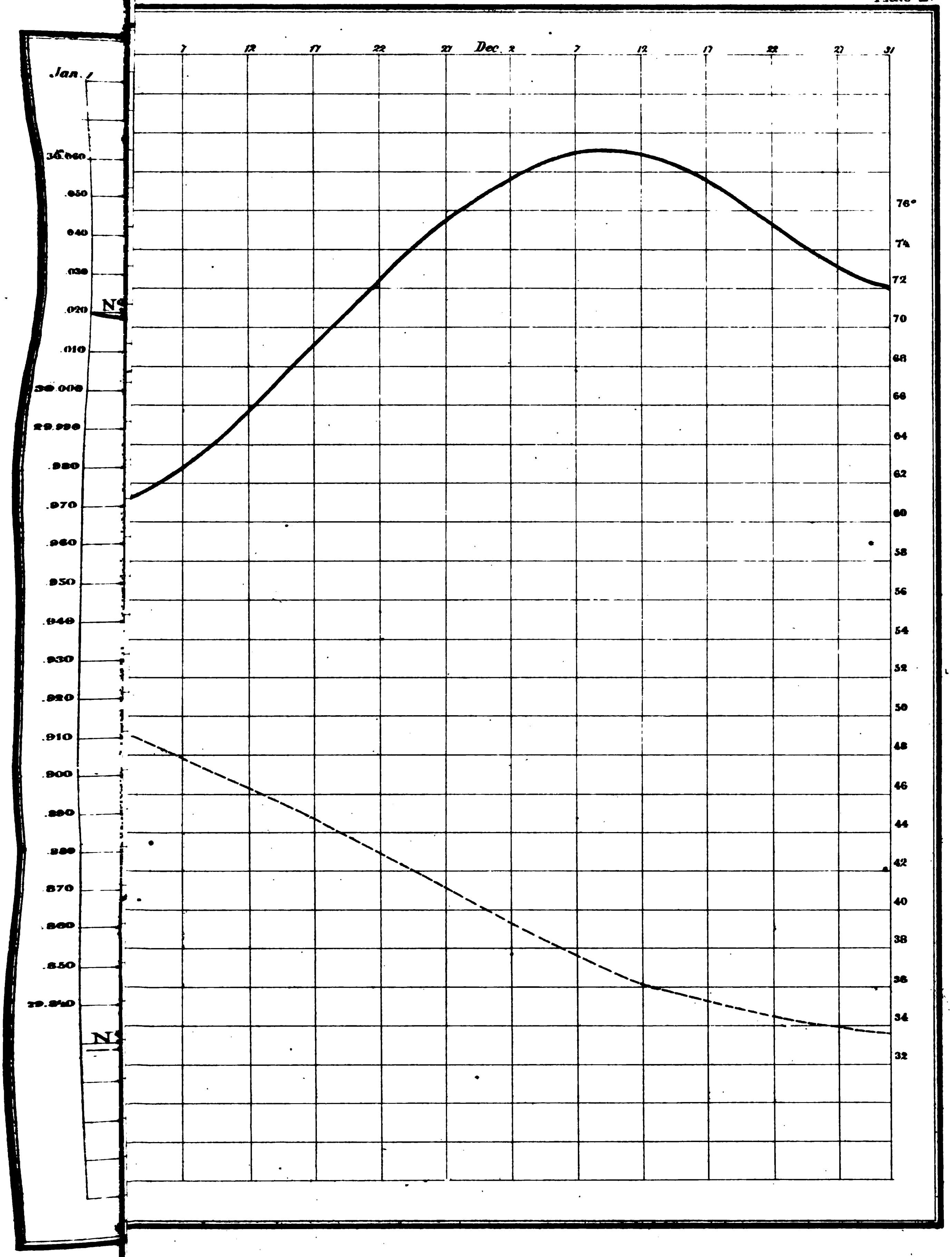
Year.	C.	C. K.	C. S.	K.	K. S.	S.	N.
1862	256	831	228	508	69	158	333
1863	304	771	225	459	80	152	339
1864	361	861	181	447	48	96	278
1865	286	920	169	465	23	86	274
1866	330	918	159	463	60	74	274
Mean	307	860	192	468	56	113	300

Table IX exhibits the mean distribution of each form of clouds in each month, as deduced from tables III to VII, inclusive, and the lower line of the table exhibits the relative mean distribution of the various forms of clouds at this station during the year.

TABLE IX.

Month.	C.	C. K.	C. S.	K.	K. S.	S.	N.
January	16	52	21	57	3	11	40
February	18	56	16	41	2	10	31
March	22	63	18	38	4	13	37
April	27	60	12	43	4	7	37
May	37	72	8	37	2	4	25
June	37	96	10	36	3	7	14
July	35	98	16	31	4	6	16
August	34	101	15	26	6	7	11
September	23	81	13	36	5	7	14
October	24	66	21	29	5	13	22
November	15	60	23	40	11	15	26
December	18	53	24	50	8	13	27
	0.13	0.38	0.08	0.20	0.03	0.05	0.13

Plate II.



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